ENVIRONMENTAL ASSESSMENT
WILDLAND FIRE MANAGEMENT PLAN
NOVEMBER 2004

HAWAI`I VOLCANOES NATIONAL PARK
HAWAI`I

SUMMARY

The Wildland Fire Management Environmental Assessment (EA) was prepared to help evaluate the impacts of proposed changes in the wildland fire management program at Hawai`i Volcanoes National Park. The proposed changes would further develop the park's fire management program to protect human life, property, and cultural resources, and maintain or restore natural resources. The EA lists many mitigating measures to be taken by park management and fire staff to reduce impacts on park visitors, surrounding communities and landowners, and the park's cultural and natural resources. The 333,000-acre park includes the newly acquired 116,000-acre Kahuku Unit; the environmental assessment is for the entire park.

The EA, prepared in accordance with the National Environmental Policy Act (NEPA), outlines the different alternatives that will be considered in revising the fire management program. The EA characterizes the impacts of these alternatives on park visitors, surrounding communities, and the park's cultural and natural resources. The public is provided 30 days to comment on this EA. The public comments will be considered in the evaluation of each alternative's potential impacts.

The EA evaluates two alternatives. Alternative 1, the no action alternative, would continue the current fire management policies, goals, and strategies that are described in the approved 1990 Fire Management Plan. These include immediate suppression of all unplanned fires of human origin and suppression of all natural fires, including lava and lightning caused fires. There would be no role for natural fire use. Small prescribed fires would be allowed on a limited basis for the purpose of ecological restoration and rare species recovery.

Alternative 2, the proposed alternative, would suppress all unplanned fires of human origin and suppress all natural fires except under the following conditions: Natural fire use would be allowed in isolated kipuka in Coastal Lowland, Alpine, and Subalpine Fire Management Units that are surrounded by extensive lava flows and where resource damage such as loss of rare species or expected invasion of alien species would not occur. Prescribed fire would be used in the Coastal Lowland and Mid-Elevation Fire Management Units to help restore native vegetation.

Under Alternative 1 and Alternative 2 fire use and prescribed fire would be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries. The Coastal Lowland, Alpine, and Subalpine Fire Management Units are in areas where there are extensive lava flows along the park boundaries. The area where prescribed fire would be used in the Mid-Elevation Seasonal Fire Management Unit is near the Hilina Pali Road, 3-10 miles from park boundaries and bordered by lava flows and dense rain forest.

Under both alternatives park staff would continue to use limited manual and chemical treatments to prevent widespread establishment of new alien grasses and facilitate revegetation of native plants; control fountain grass; maintain or establish fuel breaks in

fire prone areas or at high value resource areas, either mechanically or by establishing fire-resistant vegetation; and revegetate burned areas with fire-tolerant native vegetation if feasible and necessary. Other actions that might be proposed in the future such as major new fuel breaks or prescribed fire in new areas would require additional NEPA compliance. The EA lists many mitigating measures to be taken by park management and fire staff to reduce impacts on park visitors, surrounding communities, and the park's cultural and natural resources, and to reduce the potential for fire escape during natural fire use and prescribed fires.

The EA describes in detail the environment potentially affected by the fire management program, potential impacts, and mitigating measures. The environmental resources that are analyzed include air quality, soils, water resources and wetlands, wilderness, soundscapes, wildland/urban interface, vegetation, wildlife, threatened and endangered species, caves, visitor use and experience, socioeconomics, archeological resources, historic structures, cultural landscapes, and ethnographic resources.

The required suppression of almost all fires under both alternatives would protect fire-sensitive resources. In addition, implementation of the actions described in each alternative would be guided by Minimum Impact Suppression Tactics to protect environmental resources. These tactics are described in the EA and a summary of impacts and mitigating measures is found in Table 5, in the EA.

Alternative 2 was selected as the environmentally preferable alternative because it overall best protects and enhances park resources by allowing natural fire use and prescribed fire as tools for native ecosystem restoration, where appropriate.

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GLOSSARY OF FIRE MANAGEMENT AND HAWAIIAN TERMS USED IN THIS DOCUMENT

Anthropogenic Fire – Human caused fire.

Black Line – A fire line created by burning, usually done as part of a fire suppression operation.

Fire Line – A break in fuel made to stop the progress of potential fires.

Fire Management Unit (FMU) – An area of the park with similar fuels, fire behavior, fire effects, and fire history. Fire management objectives and strategies may vary by Fire Management Unit.

Fuel Loading – Amount of burnable biomass, including live fuels and dead fuels.

Integrated Pest Management (IPM) – A decision making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage, by cost-effective means, while posing the least possible risk to people, resources and the environment (NPS 2001).

Kipuka – A Hawaiian term referring to an island of vegetation surrounded by younger or sparsely vegetated lava flows. Plural of term is kipuka.

Makai – A Hawaiian term referring to downslope.

Mauka – A Hawaiian term referring to upslope.

Mesic – An ecological term referring to vegetation receiving intermediate amounts of rain fall, more than dry plant communities but less than wet communities or rain forest.

Minimum Impact Suppression Tactics (MIST) – Refers to guidelines that assist fire personnel in the choice of procedures, tools, and equipment used in fire suppression and post-fire rehabilitation that will maintain a high standard of caring for the land. These techniques reduce soil disturbance, impact to water quality, noise disturbance, intrusions in the wilderness, and cutting or trampling of vegetation. NPS guidelines, outlined in DO-18, are applied to site conditions, and current and expected fire behavior to determine the appropriate MIST actions. Appendix 2 provides additional guidance for determining MIST for the park.

Minimum Requirement – A decision making process in wilderness planning to determine whether or not a proposed management action is appropriate and necessary for the administration of the area as wilderness and/or does not pose a significant impact to the wilderness resources and character.

Minimum Tool – If the project is appropriate and necessary in wilderness, as determined by the minimum requirement process, the management method that causes the least impact to the physical and experiential resources is called the minimum tool.

Natural Fire – Fire resulting from natural causes. At Hawai`i Volcanoes National Park, natural fires are typically caused by lava flows and by lightning on rare occasion. When natural fire is allowed to spread in a park it is called wildland fire use.

Pali – A Hawaiian term referring to a cliff or fault scarp**.** Singular and plural is pali**.**

Prescribed Fire – Any fire ignited by management actions to meet specific objectives. A written approved prescribed fire plan must be completed and appropriate NEPA requirements followed prior to ignition. This term replaces the terms used in previous fire management documents, “management ignited prescribed fire” or “prescribed burn.”

Suppression – A response to wildland fire that results in curtailment of fire spread and elimination of all identified threats from the fire.

Ungulate – In this EA, ungulate refers to mouflon sheep and/or feral sheep, pigs, goats, and/or cattle.

Wildfire – An unwanted wildland fire.

Wildland Fire – Any non-structure fire, other than prescribed fire, that occurs in the wildland. This term encompasses fires previously referred to as both wildfires and prescribed natural fires.

Wildland Fire Use – The management of naturally ignited wildland fires to accomplish specific pre-stated resource management objectives in pre-defined geographic areas, formerly called Prescribed Natural Fire.

CHAPTER 1. INTRODUCTION

BACKGROUND

This document is an environmental assessment (EA) that was prepared to evaluate and provide an opportunity for public input to the wildland fire management program at Hawai`i Volcanoes National Park. The environmental assessment, required by the National Environmental Policy Act (NEPA), outlines the different alternatives that will be considered in revising the park's Fire Management Plan. It characterizes the impacts of these different alternatives on park visitors, surrounding communities, and cultural and natural resources in the park. The public is provided 30 days to comment on this EA.

Hawai`i Volcanoes National Park is located on the southern portion of Hawai`i Island, State of Hawai`i (see Figure 1). The 333,000 acre park includes the newly acquired 116,000 acre Kahuku unit. The environmental assessment is for the entire park.

PURPOSE AND NEED

The purpose of this federal action is to develop and improve the park's fire management program to protect human life, property, and cultural resources and to maintain or restore natural resources. The park area has been expanded 53% by the acquisition of the 116,000-acre Kahuku unit with its new fire environments. In particular, the new acquisition includes approximately 8,000 acres of cattle pastures. As cattle grazing is phased out, the grass and brush dominated pastures will become especially vulnerable to fire spread. In 2002 and 2003, fire affected nearly all the wet and mesic forest on the East Rift of Kilauea. Recovery of native vegetation in burned East Rift forests is jeopardized by an ongoing eruption and high volumes of unburned surface fuels left by the widespread fires of 2002-2003. Invasive species continue to be the main natural resource issue with wildland fire. Most park fires are carried by introduced, fire promoting species. Invasive species typically invade after wildland fire. Prescribed fire, however, is potentially a powerful tool to restore or rehabilitate damaged ecosystems or restore native species that benefit from fire. Fire and more typically fire suppression operations can irreversibly harm park cultural resources. Park fire management and resource staffs have recently developed systems and are specially trained to mitigate damage to cultural resources. Portions of the growing communities of Volcano and Ocean View that are on the park's boundaries are threatened by fire starting in the park; park resources are threatened by fire starting in the communities. With frequent lava flows, natural ignition sources are prevalent and a park policy on fires of natural origin needs to be reevaluated in terms of the most recent evidence of the impacts of fire.

The park currently has an approved Fire Management Plan that was written in 1990. Since the plan was written, additional information on fire ecology was acquired through completed studies of fire effects in the coastal lowlands and the dry `ohi`a woodlands. Techniques for rehabilitating burned areas have been developed through a series of research projects. These techniques are now being implemented in areas that were burned by large wildland fires (e.g., Broomsedge Fire, 2000; Kupukupu Fire, 2002).

Strategies for preventing fire and reducing the spread of fires once started have been tested for the last decade. Nearly all of the East Rift Zone burned in 2002 and 2003 and is vulnerable to reburning. The Kahuku Unit has added additional burnable acres, and includes a new fire environment. Finally, fire management policy in the National Park Service and other federal agencies has undergone change in the 1990s, in response to many catastrophic fire seasons on the Mainland United States and loss of life and property.

National Park Service Director's Order 18 requires "*each park with vegetation capable of carrying fire to prepare a fire management plan to guide a fire management program that is responsive to the park's natural and cultural resource objectives and to safety considerations for park visitor, employees, and developed facilities. Alternatives to be implemented will be described in detail in a draft Fire Management Plan. The environmental assessment developed in support of the Fire Management Plan will consider effects on air quality, water quality, health and safety, and natural and cultural resource management objectives*." The park's Fire Management Plan alternatives are detailed in this environmental assessment.

PARK FIRE MANAGEMENT GOALS AND OBJECTIVES

Fire management goals, strategies, and potential impacts need to be evaluated in the context of park purpose. Park purpose is based on the enabling legislation that created Hawai`i Volcanoes National Park and other federal laws that affect management of the park. On-the-ground guidance for implementing these laws is provided by National Park Service Management Policies (2001) and Hawai`i Volcanoes National Park resource management goals and strategies.

Legislation

Legislation establishing the National Park Service and Hawai`i Volcanoes National Park defines the broad purpose of the park.

The 1916 Organic Act (16 USC 1) establishing the National Park Service states that the purpose of the national parks is "*to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations*."

Hawai`i Volcanoes National Park was established by an Act of Congress (Pub Law 95-635, 16 USC Sec. 1132) on August 1, 1916. This act states that the park *"shall be perpetually dedicated and set apart as a public park or pleasuring ground for the benefit and enjoyment of the people of the United States . . . .*" The park's enabling legislation also provides for the *"preservation from injury of all timber, birds, mineral deposits, and natural curiosities or wonders within said park, and their retention in their natural conditions as nearly as possible . . . the Secretary of the Interior shall make and publish such general rules and regulations as he may deem necessary and proper for the*

management and care of the park and for the protection of property therein, especially for the preservation from injury or spoilation of all timber, natural curiosities, or wonderful objects within said park." The park's enabling legislation does not provide specific guidance for resource or fire management.

The park Master Plan (1975) states more specifically that the "purpose of Hawai`i Volcanoes National Park is to conserve volcanic features, endemic Hawaiian ecosystems, Hawaiian cultural and archeological remains, and inherent scenic views." The 2001-2005 Strategic Plan for Hawai`i Volcanoes National Park defines the purpose of the park in more detail as follows:

- *To protect, study, and monitor volcanic landscapes and processes.*
- *To protect, study, and restore native Hawaiian ecosystems and species, many of which are rare or endangered.*
- *To protect, preserve, and study cultural resources including landscapes, features, archeological or historical structures and features, and museum objects.*
- *To provide a nurturing environment for the preservation and practice of traditional Native Hawaiian culture*
- *To provide opportunities for public education, enjoyment, and safe access to the park and its resources.*

Park Resource Management Goals

The following park resource management goals, articulated in the park's Resource Management Plan (1999), guide fire management in the park:

- *Reduce the negative impacts of wildfire but use fire as a restoration tool when possible.*
- *Restore park ecosystems recently invaded by alien species through removal of key alien species followed by natural recovery; restore highly altered park ecosystems through a program of active rehabilitation to conditions as natural as practicable.*
- *Expand restoration efforts focused on localized model areas to a park-wide scale.*
- *Restore lost biodiversity in park ecosystems by recovering endangered, threatened, and rare plant and animal species, and by reintroducing locally extirpated species*
- *Protect natural and cultural resources by developing guidelines and standard operating procedures followed by all park divisions in carrying out maintenance, visitor services, and resource management functions, as well as cultural and environmental compliance.*

LOCAL FIRE ISSUES

There are several local fire issues that need to be addressed in revising the Fire Management Plan: the Kahuku pastures as a new fire environment for the park, increased potential for fire recurrence and vulnerability of native plant communities on the East Rift of Kilauea, invasive species and rehabilitation of burned areas, an expanding wildland-urban interface, and the role of natural fire.

The Kahuku Pastures as a New Fire Environment for the Park

The 116,000-acre Kahuku Ranch was acquired by the National Park Service in 2003. Although the acquired ranch is largely a natural area and over two-thirds is lightly vegetated lava flows with little fire potential, there are approximately 8,000 acres of pasture lands at lower elevations that have the potential to burn. The pastures are sparsely wooded with a continuous understory of alien pasture grass. The pastures are divided into nine grazing units of four paddocks each, with one herd per grazing unit. Each herd in each grazing unit spends approximately one week per month in each paddock. As a result, the pasture grasses are not closely cropped but provide relatively high fuel loadings of grasses, up to one foot tall. A number of pastures on the drier west and upper north areas are grazed only very occasionally or have been abandoned and are being invaded by fire-promoting invasive grasses.

The park has entered into a five year Special Use Permit (SUP) to maintain cattle grazing in the pastures. The purpose of the SUP is to maintain low fuel loadings and prevent the invasion of more flammable grasses and shrub species. It will also provide time for park resource managers to develop forest restoration techniques and secure funding for landscape-level restoration. Fuel loadings are expected to increase during the life of the Special Use Permit because the permit includes a planned phase-out of cattle grazing during the lifetime of the permit.

Increased Potential for Fire Recurrence on East Rift of Kilauea

Large fires in 2002 and 2003 in the East Rift of Kilauea increased the potential for future fires. These fires burned nearly all areas in the East Rift except for about 1,500 acres of dense tree fern rain forest near Makaopuhi and Napau Craters. Additional fires are likely to recur because of the on-going eruption and abundant available fuels. The fires of 2002 and 2003 were of low severity near ground level and did not remove surface fuels in uluhe rain forest and sword fern dominated mesic forest. The partly burned surface fuels were able to carry fire two or more times after an initial fire. Also, fires in 2002 and 2003 killed tree canopies in the forest, thus creating drier conditions and higher surface winds.

A second fire can quickly eliminate the native plant recovery that is occurring in burned areas in the East Rift. The canopies of almost all `ohi`a (see Appendix 1 for list of common and scientific names) trees were killed in burned areas but most individual trees are resprouting from the root collar. Second fires, carried in unburned deep litter and humus, have killed resprouting `ohi`a. Uluhe fern, the main understory in burned rain forest communities on the East Rift, can regenerate after fire from underground rhizomes. Rhizomes are protected from the heat of an initial fire by mats of unburned litter and humus. However, a second fire, by burning the remaining surface fuels, can heat the soil and kill uluhe rhizomes. Furthermore, a second fire can stimulate the spread of invasive plant species by removing the residual mats of surface fuels that inhibit the establishment of weedy species.

Invasive Species and Rehabilitation of Burned Areas

Fire has become a powerful, destructive force in a number of park ecosystems in the last 35 years, particularly in the dry `ohi`a woodlands of the Mid-Elevation Seasonal Fire Management Unit. Starting in the late 1960s, introduced, fire-enhancing grasses have modified the natural low frequency, small fire size fire regime in the coastal lowlands and mid-elevation seasonal ecosystems of Hawai`i Volcanoes National Park. Fire frequency in the park has increased 3-fold and fire size 60-fold since then. Fire-enhancing grasses spread in the coastal lowlands in the early 1970s after the removal of feral goats, which maintained fire-resistant annual and short-statured perennial grasses. Alien grasses spread in the dry `ohi`a woodlands, which had little history of fire because of a paucity of native grasses and other fine fuels. Since the spread of alien grasses, nearly two-thirds of the park's dry `ohi`a woodland community has burned in the last three decades.

With alien grasses altering disturbance regimes of native ecosystems, fires have enhanced the spread of alien invasive species and become destructive to many native species. Many native plants are not fire tolerant and when exposed to fire they are not likely to survive by resprouting or seeds. Other native plants might be able to survive fire, but they may not grow as quickly as some of the alien grasses. As a result, the growth of alien grasses following a fire can inhibit the growth of native species. This is particularly true in the dry `ohi`a woodlands where fires have been the most widespread at the park in recent decades. Fire reduces the abundance of native plants, comprised largely of trees and shrubs. Alien grasses become more abundant after fire. As the woodlands opened up and grass fuel loadings increased, an alien-grass fire cycle became established in the dry `ohi`a woodland. The invasion of fire-enhancing alien grasses promotes fire; fires increase alien grass and open up the forest, fostering conditions that make subsequent fires more likely or intense. The impact of fire in the other fire environments of the park is not as great as in the dry `ohi`a woodland (Mid-Elevation Seasonal). Coastal pili grassland is one of very few native communities that respond positively to fire (Tunison *et al.* 1994, D'Antonio *et al.* 2000). While many plant species within the park cannot withstand fire, pili grass, a common native grass in parts of the coastal lowlands, is an example of one species that responds positively to fire. Species such as pili and other fire tolerant species can be important in burned area rehabilitation.

Prescribed fire has proven to be a useful tool in experimental rehabilitation of fire-damaged dry `ohi`a woodland and coastal grasslands. Eight small, prescribed burns have been conducted since 1993 to test methods for establishing fire-tolerant native plant species to burned areas in the Mid-Elevation Seasonal and Coastal Lowland Fire Management Units. The species targeted for restoration are tolerant of fire, recovering rapidly from seed and/or resprouts. In experiments conducted to date, seeds of fire tolerant native species have been sown into small prescribed burns. Prescribed fire temporarily removes the alien grass mats and allows establishment of seedlings. Grasses eventually recover, but seedlings are able to survive and grow to attain

reproductive maturity. The technique of burning and seeding has proven to be effective for establishing several native, fire-tolerant plant species including mamane, iliahi, `a`ali`i, ko`oko`olau, and others, in the dry `ohi`a woodlands. Many of these species were formerly more abundant, but populations were depleted by past browsing from feral goats. Goats were removed from the park in the 1970s, but natural recovery of species was poor because of insufficient seeds in the soil. In coastal grasslands, the efficacy of using prescribed burns to restore pili grasslands is being studied. Pili is an indigenous, fire-adapted grass that once dominated the dry lowland slopes of the Hawaiian islands, as a result of Polynesian burning practices. Today, pili grasslands in Hawai`i are much reduced and are mixed or replaced by introduced grasses and woody species. Wildland fire effects studies document the positive response of pili to lava-ignited fires in recent years in the park (Tunison *et al.* 1994, D'Antonio *et al.* 2000). Two small prescribed burns conducted in mixed pili-alien grasslands show that pili abundance can increase relative to alien grasses present in the area but results vary according to the alien species present (Loh *et al.* 2003).

Expanding Wildland/Urban Interface

Residential development is intensifying rapidly along the boundaries of the park near the Volcano Golf Course Subdivision and Ocean View. In the Golf Course Subdivision area, fires driven by the characteristically strong local winds are capable of carrying fire through the subdivision and into the park, potentially affecting vulnerable and irreplaceable biological resources in Kipuka Puaulu. The Broomsedge Fire in 2000 demonstrated the potential for fire to spread from the park to the subdivision and neighboring lands. A wildland/urban interface with scattered structures exists along either side of the Mauna Loa Strip with adjacent ranches, mauka of the Volcano Golf Course Subdivision.

With the Kahuku unit, the park acquired a wildland/urban interface with Ocean View and other adjoining properties. There are broad historic lava flows between the park and Ocean View so the spread of fire between the subdivision and the park is low. However, there is a high probability of fire spread, west of Ocean View, between the forests on the southwest slopes of Kahuku and properties to the southwest, including the Nature Conservancy's Kona Hema Preserve that is west of Ocean View, a private parcel, and Yee Hop Ranch. There are continuous grassy fuels between the park and these adjoining properties, and a large fire occurred in both Kahuku and adjoining ranches in 1993. There is also the potential for fire spread between the lower Kahuku pastures and small ranches along Lorenzo Road.

A wildland/urban interface with clusters of park structures is located at the Kilauea summit. There are historic districts with multiple buildings at Kilauea Military Camp, the park headquarters, and park maintenance areas. Volcano House, a historic hotel, is adjacent to the park headquarters. There is generally a low probability of fire spread in the Kilauea Military Camp, park residential area, and park maintenance area because of landscaping or lack of vegetation, as is the case with the Jaggar Museum and Hawaiian Volcano Observatory. However, large patches of uluhe fern in the park headquarters

and maintenance area and dense patches of fire-promoting grasses on the margins of Kilauea Military Camp suggest the potential for localized fire spread under unusually dry or windy conditions.

Role of Natural and Cultural Fire

Determining the prehistoric and historic role of fire in the park is limited by the lack of precise tools to determine fire history in the Hawaiian environment. For example, the lack of annual rings in tropical Hawaiian trees precludes the development of fire histories from fire scar chronologies. This is available in many temperate areas, but not in Hawai`i. What is known is that natural and anthropogenic (human-caused) fire did occur. Geologists attempting to date lava flows have found and dated charcoal fragments and charcoal layers. This evidence suggests the occurrence of wildfires, probably of volcanic origin. Dated charcoal fragments found in sediment cores from some Hawaiian bogs also indicated that natural fire occurred in some ecosystems. Although it is not yet possible to develop a detailed fire history from this information, general patterns of fire history can be inferred. The pollen records indicate a climate alternating between wet and dry periods over the last 40,000 years (Burney *et al*. 1995, Hotchkiss unpubl.). Higher concentrations of charcoal are present in strata dominated by `ohi`a and grass pollen and lower charcoal concentrations are found in strata dominated by pollen for wet forest species. A marked increase in charcoal sediments indicates an increase in fire since European contact 200 years ago.

Detailed fire records dating back to 1924 document the park's fire history. However, the history for anthropogenic fire (human caused fire) before 1924 is partly understood for at least one ecosystem, based on research conducted outside the park. Starting nearly a millennium ago, the coastal lowlands were deliberately burned by Native Hawaiians. Fires were started to clear forest for agriculture and to stimulate the growth and abundance of pili grass and other desirable plants. Anthropogenic burning by prehistoric Native Hawaiians is thought to be responsible for the deforestation of the coastal lowlands in Hawai`i (Kirch 1982). A detailed analysis of historic accounts in the Hilo area of the Big Island indicate that there was a broad belt of cleared land up to 1,500 foot elevation (McEldowney 1979). Although a similar historical analysis has not been done for the park, Native Hawaiian burning practices most likely modified the coastal lowlands of the park below 500-foot elevation and may have also affected lower portions of the dry `ohi`a woodlands upland to 1,500-foot elevation.

Since 1924, the park's fire history has been carefully documented. Fire frequency and size have increased dramatically starting in the late 1960s (Loh, unpubl.). Approximately one-half of the fires started in the park resulted from lava flows, and lightning has caused a few fires. From 1924 to 1963, there were 35 fires or 0.9 fires per year on average. These fires burned 215 acres or 6.1 acres per fire on average. Most of these small, infrequent fires were concentrated in visitor use areas along the rim of Kilauea Caldera, in pastures leased to cattle ranchers on the slopes of Mauna Loa, and in the vicinity of Civilian Conservation Corps camps or work projects. From 1964 to

1995 there were 97 fires or slightly more than three fires per year. These fires burned approximately 34,450 acres or an average of 355 acres per fire.

The approximately three-fold increase in fire frequency and nearly 60-fold increase in fire size from 1964-1995 followed the introduction and spread of alien fire-promoting grasses in the 1960s. (Stone 1959, Mueller-Dombois and Fosberg 1974, D'Antonio *et al.* 1998, D'Antonio and Vitousek 1992). The invasion of some grass species may have been facilitated by high densities of feral goats, which suppressed potentially competitive native woody vegetation.

The invasion and spread of fire-promoting grasses in the mid-elevation seasonal and coastal lowland ecosystems (FMU 5 and 6) coincided with an era of renewed volcanic activity that started during the late 1970s and continues to the present. Although it is not possible to strictly separate the increased potential for fire ignitions from lava flows and humans, from the impact of invading fire-enhancing grasses, the fire record is clear. Most of the park's fire activity since the late 1960s occurred in the two ecosystems of the park that were most heavily invaded by the fire promoting grasses.

To date, the park has taken a very cautious approach with fires of natural origin or fire use. All fires, regardless of origin, have been suppressed because fires within the park tend to promote the spread of invasive plants and the loss of many native plant communities. A critical goal of resource and fire management is maintenance and restoration of native ecosystems. Also, the natural fire regime has been altered because in many cases these fires were carried by invasive grasses, an unnatural fuel.

However, not all fires result in negative impacts on native vegetation or positive impacts on exotic vegetation. Fire effects studies and prescribed burns in the coastal lowlands demonstrate that fire can enhance the spread of native pili grass (Tunison *et al*. 1994, Loh *et al*. 2003). In the coastal lowlands, there are fuel beds in isolated kipuka that are bordered by sparsely vegetated lava flows. These fuel beds may benefit from allowing fires of natural origin to spread. Fire could occur in these kipuka without risk of fire spreading into adjacent environments, where fire facilitates the spread of invasive species. There are also environments in the park, particularly in the alpine and subalpine, where the vegetation is sparse and the risk of fire spread is minimal. Fire effects studies have demonstrated that in these environments, a number of native species respond favorably to fire and there are few invasive species in these environments.

IMPACT TOPICS CONSIDERED

Impact Topics Addressed and Analyzed

The public has expressed interest in and need for a park fire management/protection plan (September 18 and October 21-23, 2003, public scoping meetings on National Park Service management of the newly acquired Kahuku Unit). Impact topics are the resources of special concern that could be affected by the range of fire management

alternatives. Specific impact topics are identified below to focus the analysis of alternatives on the most relevant subject matter and resources of special concern.

Air Quality. The federal 1963 Clean Air Act stipulates that federal land managers have an affirmative responsibility to protect a park's air quality related values (including visibility, plants, animals, soils, water quality, cultural resources, and visitor health) from adverse air pollution impacts. The park is designated as a federal "Class I" airshed. This places the most stringent constraints on construction and operation of pollution-emitting facilities in the park's vicinity. Air quality would be affected in the short-term during any type of ignition event; therefore, it is analyzed as a relevant impact topic.

Soils. National Park Service (NPS) Management Policies (2001) require the consideration of impacts on topography and soils. There is potential for increased erosion particularly after hot, intense fires, which consume nearly all vegetative litter and volatilize soil organic matter. Fires on steep slopes have greater potential to cause erosion. Soils may be potentially affected by fire; therefore, it is included as an impact topic.

Water Resources and Wetlands. National Park Service policies require protection of water resources consistent with the Clean Water Act. Fire potential is extremely low in areas containing water resources and wetlands. However, there is a low risk that water quality may be affected by sedimentation from soil erosion, and contamination from chemicals (e.g., retardant, diesel, herbicides) applied upslope during suppression and fuel reduction activities. Consequently water resources are included as an impact topic.

Wilderness. The Wilderness Act, National Environmental Policy Act (NEPA), and NPS Management Policies (2001) require assessment of effects on wilderness values. Approximately 60% of the older portion of Hawai`i Volcanoes National Park is designated wilderness. NPS Management Policies requires that the NPS manage wilderness areas in parks in such a manner that will leave them unimpaired for future use and enjoyment as wilderness. Wilderness may be potentially affected by fire; therefore, it is included as an impact topic.

Soundscape. NPS Management Policies (2001) require that parks maintain their natural soundscapes. Fire management activities may impact natural soundscapes; therefore, soundscapes will be considered as an impact topic.

Wildland/Urban Interface. DO-18, Wildland Fire Management, stipulates that firefighter and public safety must be first priority in all fire management activities. The Wildland/Urban Interface (WUI) will be considered as an impact topic.

Vegetation and Wildlife. The National Environmental Policy Act requires analysis of impacts on all affected components of the ecosystem, including native biotic communities of plants and animals. NPS Management Policies (2001) requires maintenance of native ecosystems and communities, including their natural abundance, diversity and ecological integrity. Fire plays an important role in changes to vegetative

cover, which in turn affects wildlife habitat and overall ecological health; therefore, effects on vegetation and wildlife are analyzed as impact topics.

Threatened and Endangered Species. The Endangered Species Act requires disclosure of impacts on all federally threatened or endangered species. There are 25 threatened and endangered plant species and six threatened and endangered vertebrate species in the park. NPS Management Policies requires that all these will be managed for their natural distribution and abundance. Threatened and endangered species will be an impact topic in this assessment.

Caves. Lava tube caves are widespread in the park. They contain geological, cultural, paleontological, and biological resources, which may be affected by fire or fire suppression operations. The Federal Cave Protection Act and NPS Management Policies (2001) require federal agencies to protect cave resources; therefore, caves are included as an impact topic.

Visitor Use. The mission of the NPS, as described by its Organic Act of 1916, states the purpose of all parks is to ". . . conserve the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same . . . ." Scenic values, recreational activities, and general visitation within and around fire-treated areas may be temporarily impacted, thus visitor use will be considered as an impact topic.

Socioeconomics. Prolonged fire operations that sometimes occur with lava ignited wildland fires may result in local purchases from caterers, helicopter vendors, lodging and bed and breakfast establishments, hardware and building supply stores, and other local vendors. The National Environmental Policy Act (NEPA) considers "impacts to the human environment" to include any effects of federal actions on the social and economic well being of communities and individuals. Therefore, the socioeconomic impacts of fires will be analyzed.

Prime or Unique Farmlands. The Council on Environmental Quality requires federal agencies to assess the effect of their actions on farmland soils classified by the U.S. Department of Agriculture's Conservation Service (NRCS) as "prime" or "unique." Prime or unique farmland is defined as soil that particularly produces general crops such as common foods, vegetables, and nuts. There is a five acre Macadamia nut orchard adjacent to the lower Kahuku pastures. There is an approximately 3,500 acre Macadamia nut orchard east of Ocean View and north and west of the Kahuku Unit. There is also an approximately 40 acre vineyard located adjacent to the park next to the Volcano Golf Course Subdivision. Therefore, prime or unique farmlands will be analyzed.

Cultural Resources. All National Park Service programs affecting cultural resources are subject to the provisions of the National Historic Preservation Act (NHPA), the National Environmental Policy Act, the American Indian Religious Freedom Act (AIRFA), the Archeological Resources Protection Act (ARPA), the Advisory Council on Historic Preservation's (ACHP) regulations regarding "Protection of Historic Properties"

(36 CFR 800), the Secretary of the Interior's "Standards and Guidelines for Archeology and Historic Preservation," and the "Federal Agency Responsibilities under Section 110 of the National Historic Preservation Act." Other applicable legislation and regulations and specific management procedures are detailed in NPS Management Policies and in the Directors Order for Cultural Resource Management (DO-28). Fire and fire suppression operations may affect cultural resources, which include archeological sites, historic structures, cultural landscapes, and ethnographic resources; therefore, it is included as an impact topic.

Impact Topics Considered and Dismissed

Environmental Justice. Executive Order 12898, "General Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires all federal agencies to incorporate environmental justice into their missions by identifying and addressing disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities. The communities surrounding the park contain a mix of incomes and ethnic backgrounds and are not considered predominately minority or low-income. The proposals contained in the Fire Management Plan would not have adverse impacts on minorities and low-income populations and communities; therefore this topic is not addressed further.

Public Safety. Visitors are confined to roads and fire incident areas are closed. Visitors on trails or in the park backcountry are evacuated during fires. Firefighter safety is regulated by DO-18 and is the highest priority in the park's fire management program. Therefore, public safety is not an issue to be analyzed in this environmental assessment.

Firefighter Safety. The safety of firefighters is the highest priority in the Fire Management program. Safety protocols and standards will be described in the Fire Management Plan. Safety considerations will not be compromised and therefore safety is not an issue to be considered in this EA.

Indian Trust Resources. Secretarial Order 3175 and EDM95-2 require federal agencies to address environmental impacts of their proposed actions on Indian Trust Resources in any environmental document. There are no Indian Trust Resources in Hawai`i. Therefore this topic is dismissed as an impacts topic in this document.

SCOPING

Multi-day scoping sessions were held on the park's fire management program and plan. In October 1996 a two day meeting was held with fire researchers, resource managers, and Hawai`i State and County fire personnel. Information about park programs, fuels, fire effects, fire policy, and fire strategies were shared formally by presentation, question and answer sessions, and an afternoon field trip. An intensive, detailed three-day scoping session occurred in June 2000, with researchers and fire managers from

Hawai`i and the Mainland addressing fuels, fire behavior, and fire effects. In 2001 and 2003, two After Dark in the Park fire presentations were given to the public. The 2001 presentation was on the Broomsedge Fire (Mid-Elevation Seasonal Fire Management Unit) and the 2003 presentation was on the Kupukupu Fire (Mesic/Wet Forest Fire Management Unit). Discussion topics included restoration, ecological impacts, and fire suppression policy and strategy for each fire, as well as the history of conducting prescribed fire for ecological restoration research. Public scoping meetings were held September 18, and October 21-23, 2003, to receive public comments on National Park Service management of the newly acquired Kahuku Unit. Fire was a topic that repeatedly came up and public comments included: 1) What kind of plan or capacity is planned in the event of a forest fire? And 2) Develop a fire management/protection plan.

The environmental assessment will be sent out to the interested and affected public, agencies, Native Hawaiian organizations, local libraries, and the state library for a thirty-day review. Notice of the environmental assessment's availability for review will be published in local newspapers and the environmental assessment will be posted on the park's web page.

CHAPTER 2. ALTERNATIVES INCLUDNG THE PROPOSED ACTION

ALTERNATIVE 1 – NO ACTION

Continue current fire management policies, goals, and strategies described in the approved 1990 Fire Management Plan. These include immediate suppression of all unplanned fires of human origin and suppression of all wildland fires, with no role for wildland fire use (that is, all lightning and lava caused fires will be suppressed). The no action alternative provides for experimental use of prescribed fire for ecological restoration and for rare species recovery. Prescribed fire would be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries.

ALTERNATIVE 2 – PROPOSED ACTION

This alternative includes all changes to be made to the park's Fire Management Plan: All unplanned fires of human origin will be suppressed. All fires of natural origin will be suppressed except for fires in isolated kipuka in the Coastal Lowland, Alpine, and Subalpine Fire Management Units that are surrounded by extensive lava flows and where resource damage such as loss of rare species or expected invasion of alien species would not occur. Prescribed fire will be used to help restore native vegetation in the Coastal Lowland and Mid-Elevation Seasonal Fire Management Units.

Fire use and prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries. The Coastal Lowland, Alpine, and Subalpine Fire Management Units are in areas where there are extensive lava flows along the park boundaries. The area where prescribed fire will be used in the Mid-Elevation Seasonal Fire Management Unit is near the Hilina Pali Road, 3-10 miles from park boundaries and bordered by lava flows and dense rain forest. The Mid-Elevation Seasonal Fire Management Unit does extend up to the Volcano Golf Course Subdivision; however, fire use (natural fire) is not proposed for this Fire Management Unit and prescribed fire will not be allowed in this portion of the unit.

Alternative 2 is the park's preferred alternative.

Table 1. Summary of Alternatives.

Alternative	Fire Suppression	Wildland Fire Use	Prescribed Fire	Hazard Fuel Reduction	Fuel Breaks
Alternative 1	Yes	No	Limited to small research burns	Includes fountain grass control and potential for control of other species	Includes maintaining existing break and NEPA compliance for new breaks
Alternative 2	Yes	Potential for fire use in Coastal Lowland,	Potential for restoration in Coastal Lowland and	Same as above	Same as above

		Subalpine, and Alpine FMUs in isolated kipuka	Mid-Elevation Seasonal FMUs		

Alternative 2 is the preferred alternative.

Actions Common to Both Alternatives

Some fire management actions will continue to be taken under both alternatives (Table 1). The park will continue to suppress unplanned fires of human origin. The park will continue to control invasive fountain grass, a potentially hazardous fuel that colonizes young, sparsely vegetated lava flows and dry forests and shrublands. Limited use of manual and chemical treatments will continue to prevent the widespread establishment of new alien species and facilitate native plant revegetation, including rare plants. The park will maintain or establish fuel breaks in fire-prone areas or in high value resource areas, either mechanically or by establishing fire-resistant vegetation. The park will revegetate burned areas with fire-tolerant, native vegetation environments if feasible and necessary.

The major differences between the alternatives are 1) that *Alternative 2* allows for an expanded use of prescribed fire as a management tool rather than just experimentally in the coastal lowlands and the mid-elevation seasonal woodlands. And 2), that *Alternative 2,* for the first time in the park, opens the possibility of allowing lava or lightning caused fires to burn in the coastal lowlands, subalpine, or alpine zones in isolated kipuka if the expected fire effects are not deleterious or they may benefit the resources.

Additional NEPA Compliance Needed

This environmental assessment does not address all possible actions under the two alternatives. For example, both alternatives allow for the establishment of fuel breaks but neither specifies new fuel break locations or specifications. Constructing a new fuel break could require additional NEPA compliance. Control of additional hazardous fuels could require another NEPA process. Under the second alternative, this EA will address impacts of prescribed fire in the Coastal Lowland and Mid-Elevation Seasonal Fire Management Units and fire use in the Coastal Lowland, Subalpine, and Alpine Fire Management Units. Prescribed fire as a management tool and fire use in other Fire Management Units will require additional NEPA compliance.

Alternatives Considered and Dismissed

These alternatives were considered and dismissed:

1. *Allow all fires of natural origin to spread under appropriate conditions*.

2. *Use mechanical, manual, and chemical treatments on a landscape scale to reduce hazardous fuels.*

Allow all fires of natural origin to spread under appropriate conditions. Over one-half of the fires in the park in the last three decades have been caused by lava flows (Tunison *et al.* unpublished data). Several lightning fires have been documented, one of which spread beyond a single lightning-struck tree (Tunison and Leialoha 1988). Of course, many Mainland parks allow lightning caused fire to spread naturally under certain conditions. However, for over two decades Hawai`i Volcanoes National Park staff has suppressed all fires, regardless of origin. The main reason is that fire from lava flows and lightning can have the same undesirable effects on native plant communities as fire from human causes. Both can cause the loss of native species and enhance the spread of invasive species. Lava flow fires and lightning fires are carried largely in unnatural fuels, specifically in fire-enhancing grasses or ferns. Nearly all lightning-caused fires that have spread beyond a single tree have been carried in alien grass resulting in the loss of native species and an increase in the abundance of alien grasses. A few lava flow fires have been documented in native uluhe fern fuels, although the effects of these fires have not been monitored.

Unsuppressed fires of natural origin could readily spread into areas where fire is not desirable. The park is relatively small and fires may readily spread from the park to surrounding areas. Also, the park has a high diversity of environments in close proximity to each other. Even if fires of natural origin began in native vegetation and their impacts might be acceptable, they may readily spread into ecosystems in which their impacts are unacceptable. For example, a fire may start in native uluhe rain forest, which may recover. However, it may readily spread into the dry `ohi`a woodlands where it would be carried by alien grasses and cause the loss of native trees and shrubs and make alien grasses more abundant.

Use mechanical, manual, and chemical treatments on a landscape scale to reduce hazardous fuels. In the park, introduced, fire promoting grasses account for the altered fire regime and fire effects harmful to native species and ecosystems. Alien grasses are the dominant ground cover in the coastal lowland, mid-elevation seasonal, and Kahuku pasture fire environments. Removing or reducing these grasses/fuels would reduce fire frequency, size, and impacts on native ecosystems. However, mechanical and chemical treatments to reduce fuel loads are not desirable or feasible on a landscape scale given the widespread distribution of alien grasses in the park. Manually reducing them by hand pulling is too labor intensive. Hand clearing of alien grasses over a two year period in a one-half acre research plot required hundreds of hours of hand-weeding to remove new grass seedlings (D'Antonio *et al*. 1998). Use of mechanical devices such as tractors could be in conflict with NPS Management Policies for natural areas because of the intrusion, ground disturbance, and damage to non-target vegetation and cultural resources. In fact, soil disturbance created by manual or mechanical removal of grass could create ideal conditions for invasive grass establishment. Mechanized equipment would only be used to construct fire control lines

on existing fuel breaks or previously constructed fuel breaks where cultural and natural resource surveys had been conducted, or with the Superintendent's approval.

Environmentally Preferable Alternative

Alternative 2 is the environmentally preferable alternative. This alternative includes all changes to be made to the park's Fire Management Plan: All unplanned fires of human origin will be suppressed. All fires of natural origin will be suppressed except for fires in isolated kipuka in the Coastal Lowlands, Alpine, and Subalpine Fire Management Units without a chance of fire spread beyond the kipuka or potential for resource damage. Prescribed fire will be used to help restore native vegetation in the Coastal Lowland and Mid-Elevation Seasonal Fire Management Units.

Similar to *Alternative 1*, the park will continue fire management actions to reduce hazardous fuels and prevent fire spread. The park will continue controlling invasive fountain grass, a hazardous fuel that colonizes young, mostly barren lava flows and dry forests and shrublands. The park will maintain or establish fuel breaks in fire-prone areas or in high value resource areas, either mechanically or by establishing fire-resistant vegetation. The park will revegetate burned areas with fire-tolerant native vegetation environments if feasible and necessary. The limited use of manual and chemical treatments to prevent the widespread establishment of new alien grasses and facilitate revegetation of native plants, including rare plant recovery, is allowed.

Alternative 2 was selected as the environmentally preferable alternative because it overall best protects and enhances park resources. Both alternatives protect park resources and prevent the spread of invasive species by requiring the suppression of fires, both from human origin and natural origin; preventing the spread of fountain grass; using fuel breaks as a strategy; and encouraging revegetation of burned areas. The environmentally preferable alternative, by applying the knowledge gained in the last decade, broadens the use of prescribed fire as a management tool for restoring native vegetation in the Coastal Lowland and Mid-Elevation Seasonal Fire Management Units, areas of the park altered by invasive weeds. *Alternative 2* allows the spread of lightning or lava caused fires in small, isolated kipuka in the coastal lowland, subalpine, and alpine zones, which will provide opportunities for evaluating fire effects, and the use of fire as a restoration technique. However, these fires will not be allowed to spread within these kipuka if they will enhance the spread of invasive vegetation to the detriment of recovering native vegetation.

Alternative 1 was not selected as the environmentally preferred method. Under the previous Fire Management Plan, restoration of communities highly altered by invasive grasses (Coastal Lowland and Mid-Elevation Seasonal Fire Management Units) was opportunistic, and largely limited to areas where natural wildfires occurred. Prescribed fire use was experimental and focused on answering narrow research questions; fire size was small, and limited to isolated kipuka. Under these conditions, areas with the greatest need or highest potential for native plant restoration were not necessarily

included. *Alternative 2* approaches long-term restoration of the landscape, by incorporating the planned use of fire.

Mitigation to Be Used under These Alternatives

Minimum Impact Suppression Tactics (MIST)

Under both alternatives, all fire suppression and prescribed fire operations will be guided by the NPS guidelines, outlined in DO-18, RM-18, for determining the appropriate Minimum Impact Suppression Tactics (MIST) to protect wilderness, visitor experience, cultural resources, native ecosystems, native flora and fauna, and threatened or endangered species. Appendix 2 provides additional guidance for determining MIST in the park. Minimum impact suppression techniques used at the park include the following approaches:

- Deploy resource advisors on all fires. Use Resource Advisors to evaluate suppression tactics so that they are commensurate with land/resource objectives and minimize impacts on cultural and natural resources.
- Train crews in recognition of cultural and natural resources for purposes of avoiding and protecting features in line construction and rehabilitation, and reporting these resources to Resource Advisors.
- Use long line remote hook in lieu of constructed helispots when feasible.
- Use natural openings as far as practical for helispots if clear of cultural resources.
- Select fire line construction techniques, tools, and equipment that have the least impact on the environment.
- Give preference to use of water, including salt water drops in coastal areas, and black line techniques.
- Rehabilitate fire lines if necessary.
- Use mechanized equipment to construct fire control lines only on existing fuel breaks or previously constructed fuel breaks, e.g., the Kipuka Nene/`Ainahou fuel break, where cultural and natural resource surveys have been conducted, or with the Superintendent's approval.
- Rehabilitate campsites, incident command post, staging areas, helispots, etc., to as natural conditions as possible. Pack out all garbage, remove all signs of human activity (flagging, etc.), fill in latrine sites, etc.

In addition to these Minimum Impact Suppression Tactics, the following mitigation will be used to protect resources:

Air quality. Prescribed fire will be conducted only when conditions for smoke dispersal are favorable. This requirement will be written into prescribed fire plans as an element of the prescription. Park visitors and local communities will be informed about planned prescribed fires and the possibility of seeing smoke, as well as the objectives of the fire.

Soils and Topography. Erosion after prescribed fire will be minimized, especially in sites with archeological resources that may be affected by soil erosion, by avoiding hot,

intense fires. Integrated Pest Management strategies will be employed to minimize or avoid soil contamination with chemicals during hazard fuel reduction or restoration after fire.

Water Resources. Use of herbicides in hazard fuel reduction or foam during fire operations will be avoided when there is a potential for contamination of waterways (based on proximity, wind direction, wind speed, size and frequency of loads, etc.). Retardants are not used in the park. Consult with Resource Advisors to determine safe distance from water resources to avoid contamination. Reduce impacts from sedimentation by minimizing soil disturbance upslope of wetlands.

Wilderness. A Minimum Requirement analysis and Minimum Tool selection process will be followed during fire operations in wilderness. The Minimum Requirement analysis is a two-step process:

1. First determine whether or not a proposed management action is appropriate and necessary for the administration of the areas as wilderness and/or does not pose a significant impact to the wilderness resources and character.

2. If the project is appropriate and necessary in wilderness, the management method is selected that causes the least impact to the physical and experiential resources. This is called the Minimum Tool.

Because the park's Wilderness Management Plan is in the draft stage, the chapter dealing programmatically with Minimum Requirement/Minimum Tool for fire operations does not yet apply. The Minimum Requirement/Minimum Tool decision making process to be followed for fire operations is outlined in a decision tree illustrated in Appendix 2 and is included in the park's draft Wilderness Management Plan. Resource Advisors will provide advice to the Incident Commander and park Superintendent and make recommendations for actions affecting wilderness following the Minimum Requirement/Minimum Tool decision-making process and Appendix 2.

In many cases, MIST protocols may be deemed to be the minimum tool and be followed in fire operations in wilderness. In other cases, standards may be stricter than MIST for wilderness.

Wildland/Urban Interface. Fire use and prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries. The Coastal Lowland, Alpine, and Subalpine Fire Management Units are in areas where there are extensive lava flows along the park boundaries. The area where prescribed fire will be used in the Mid-Elevation Seasonal Fire Management Unit is along the Hilina Pali Road, 3-10 miles from park boundaries and bordered by lava flows and dense rain forest. The Mid-Elevation Seasonal Fire Management Unit does extend up to the Volcano Golf Course Subdivision; however, fire use (natural fire) is not proposed for this Fire Management Unit and prescribed fire will not be allowed in this portion of the unit.

Vegetation, Wildlife, and Native Ecosystems. Special biotic communities and rare plants have been identified and mapped for fire management purposes. Resource Advisors in fire suppression and prescribed fire operations will work with the fire Incident Commander to include protection of unique or significant native ecosystems, flora, and fauna as incident objectives. Fires started by lightning or lava flows and prescribed fire will be not be allowed in kipuka in the coastal, subalpine, and alpine zones if they contain unique or special biological resources, unless fire responses would be favorable for native vegetation and unfavorable for alien grasses. Prescribed fire will be excluded from areas where valuable resources could be potentially harmed by fire.

The impacts of fire use in the coastal lowlands, subalpine, and alpine zones will be closely monitored. If vegetation changes after fire indicate unacceptable levels of invasive species establishment, modify the fire use policy accordingly at the annual fire review.

Initiate research and monitoring of fire effects on birds and invertebrates. No studies have been conducted and impacts are inferred from impacts on vegetation.

Threatened and Endangered Species and Species of Special Concern. These have been mapped and their locations will be taken into account in planning suppression and prescribed fire operations. These species will be avoided or protected in fire operations unless fire impacts are known to be favorable. Resource Advisors will tag threatened, endangered, and species of special concern to be protected from impacts of fire operations.

Caves. Firefighters will be prohibited from entering caves. This will be incorporated into Incident Action Plans and briefings. Resource Advisors will flag cave entrances to be avoided. Caves contain a number of unique geological formations, as well as cultural, paleontological, and biological resources. Cave ecosystems are supported by tree roots penetrating cracks and the cave openings, and organic slime materials leached from above.

Visitor Use and Experience. Visitors will be kept out of harm's way and park roads and facilities will be closed if necessary, with appropriate explanation of reasons for the closure. Wildland fire use and prescribed fire will be interpreted on-site, whenever practicable.

Cultural Resources - Archeological Resources, Historic Structures, Cultural Landscapes, and Ethnographic Resources. The Minimum Impact Suppression Tactics will be followed to protect cultural resources. Helicopter water drops around archeological features will be high, spreading the water, rather than low drops that could dislodge rocks from features. A Cultural Resource Advisor (in most cases it will be an Archeologist) will be assigned to all fires as part of the Resource Advisor team. Additional Cultural Resources Advisors will be assigned as needed. The Cultural Resource Advisor will brief fire personnel on the identification, distribution, and

sensitivity of cultural resources, including archeological resources, historic structures, cultural landscapes, and ethnographic resources. The Cultural Resource Advisor would identify when additional cultural resources expertise and/or staff are needed. A Cultural Resource Advisor will accompany crews in the field, flag sensitive features to be avoided by crews, help to mitigate potential impacts in line construction and mop up, and educate fire personnel in the field on cultural resource values in the fire area.

All areas proposed for prescribed fire would be first surveyed for cultural resources prior to using prescribed fire. If any cultural resources were discovered within the proposed prescribed fire site, a determination would be made as to the effects of the proposed prescribed fire on these resources. Pre-fire archeological surveys may include subsurface testing to help document previous burn regimes or to provide information useful to establish plant species. If adverse effects were anticipated, section 106 consultation would occur. If adverse effects couldn't be mitigated the prescribed fire would not be carried out. To protect historic buildings and other cultural resources with a potential to be affected by wildland fire, fire prevention and hazard fuel reduction site plans will be developed as part of the park's fire management program. The effects of prescribed and wildland fire on cultural resources will be monitored to determine their impacts. Post-fire surveys may be conducted to document impacts or discover new archeological features and sites.

Mitigating Risk of Fire Escape during Prescribed Fire

Prescribed fire use is limited to portions of the Coastal Lowland and Mid-Elevation Seasonal Fire Management Units that are removed from the wildland/urban interface. Prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries. Each prescribed burn project will follow a continuous risk management process as outlined in RM-18. This includes the formulation of a Prescribed Burn Plan where a complexity analysis is performed to identify the initial break points, prescription parameters, holding actions, and contingency planning needed to prevent fire escape. If the prescribed fire escapes or the fire effects are unacceptable, the prescribed fire is declared a wildfire and the appropriate management response is initiated.

Mitigating Risk of Fire Escape during Wildland Fire Use

Once a candidate natural fire is detected a determination of the alternative actions and their potential risks and benefits are evaluated in a multi-stage process.

Stage I of the Wildland Fire Implementation Plan (WFIP) must be completed within 2 hours. Stage I consist of two components: The fire situation and the initial Go/No Go decision. Fuel models, fuel conditions, current and expected weather, current and expected fire behavior, and the availability of resources shall all be considered in the initial decision. A relative risk rating shall also be completed prior to the Agency Administrator review and signature. The elements to consider are: 1) Threats to life, property, or resources that cannot be mitigated. 2) Unacceptable effects on cultural and

natural resources. 3) Unacceptable risk indicators to the Agency Administrators identified in the Wildland Fire Relative Risk Rating worksheet.

If the candidate Wildland Fire is approved, a Stage II assessment must be completed within 24 hours. At this time a fully qualified Fire Use Manager (FUMA) will be ordered and assigned. In Stage II a more thorough fire behavior and risk assessment will be developed utilizing the best available science.

A Stage II periodic fire assessment will determine if and when Stage III will be prepared and a Fire Use Management Team will be ordered. The purpose of Stage III is to fully evaluate both fire potential and management capability. Operational activities are developed and a detailed long-term risk assessment, modeling potential fire spread, is completed. Defining the Maximum Manageable Area (MMA) is completed with detailed information regarding threats to values at risk located within this geographical area. In a Stage III assessment the likelihood that the fire will reach defined areas within, or potentially exceed the MMA, must be considered. Contingency actions for a possible breach of the MMA must be developed. The entire intent of Stage III is to identify management action points and subsequent actions that increase the probability of achieving objectives established through the planning process for an individual fire. The Agency Administrator may at any time deem the risk or effects unacceptable and declare the Wildland Fire Use event a wildfire and take the appropriate management response including aggressive suppression. If the Wildland Fire Use event threatens the pre-determined Maximum Manageable Area (MMA), the event can once again be declared a wildfire and the appropriate management response initiated.

Mitigating Risk of Herbicide Use

Chemical treatments are limited to initial knockdown of grasses to 1) prevent widespread establishment of hazardous fuels (e.g., fountain grass), and 2) temporarily remove alien grasses to facilitate native revegetation efforts. No long-term recurrent use of chemicals is used in a specific area. In both cases, affected areas are limited to individuals treated (< 2 ft diameter), or the restoration plot (< 20 m^2). In addition, application of herbicides is guided by Integrated Pest Management (IPM), a decision making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage, by cost-effective means, while posing the least possible risk to people, resources, and the environment (NPS, 2001).

CHAPTER 3. AFFECTED ENVIRONMENT

NATURAL ENVIRONMENT

Air Quality

Clean air is an important resource at Hawai`i Volcanoes National Park. The park is a Class I airshed under the Clean Air Act. There are views of Mauna Loa from many parts of the park and sweeping views of the ocean and coastline from the Chain of Craters Road. Human-caused air pollution is negligible on the Big Island because of its low population and paucity of industrial facilities. The park is affected by persistent, strong trade winds, and areas upwind of the park are very lightly populated. A plume of particulates is produced at the ocean entry of the lava flow, affecting localized viewing areas along the coast. However, Pu`u `O`o and Halema`uma`u Craters continuously produce very large quantities of sulfur dioxide and sulfate particulates. These gases of volcanic origin are locally called “vog.” These are generally carried by trade winds in distinct plumes to the west or southwest and cross the park, obscuring local vistas near the sources, depending on the direction of the wind and the plume. At night, land breezes typically take the vog plume directly downhill to the south. Visibility deteriorates generally downwind and vog produced by the volcano can obscure views of Mauna Loa or the coastline in the southwest part of the park. During the winter months, when trade winds may be replaced by weak onshore or cold front winds, the sulfur dioxide and particulate plumes move to the northwest or northeast and can blow over the summit of the Kilauea volcano.

Soils

The park is located on the south slopes and summits of two of the most active volcanoes in the world, Kilauea and Mauna Loa. It includes most of the East Rift Zone and Southwest Rift Zones of Kilauea and the Southwest Rift Zones of Mauna Loa. Ninety percent of Kilauea is covered by lava every 1,000 years. Eleven percent of the park lands on Kilauea volcano have been covered by lava flows in an on-going 21-year-old eruption. New lava flows cover 40% of Mauna Loa’s Southwest Rift Zone every 1,000 years. As a result, much of the surface geology and soils of the park are very young.

Soils have developed from organic matter and tephra (largely ash but also cinder and pumice) fallout, mostly from pyroclastic surges or ash eruptions of Kilauea. Soil depth is a function of the age of the lava flows, proximity to Kilauea summit, and precipitation. Older flows have had greater opportunity to receive an ash eruption, areas near the summit receive greater ash fallout, and organic deposition is greater in wetter areas. A pattern of younger lava flows partially covering older, vegetated lava flows creates an island of vegetation surrounded by younger lava flow. This is the vegetation phenomenon known as the Hawaiian kipuka.

Slopes of the park's two shield volcanoes are very gentle, except for steep fault scarps, the wall of pit craters, or sides of cinder cones. Natural erosion is a significant process in localized areas of the park. Such areas include the higher, active fault scarps on the south flank of Kilauea and the sparsely vegetated, ash dominated areas of the Ka`u Desert and other locations subject to occasional heavy rains. Erosion from heavy browsing and trampling by feral animals is not a problem in the older portion of the park where these animals have been controlled. Erosion from invasive ungulates is a problem in portions of the Kahuku Unit.

Water Resources and Wetlands

Hawai`i Volcanoes National Park has highly modest water resources. Volcanic substrates on the slopes of Mauna Loa and Kilauea are very young, with little soil, and highly porous. There is no natural permanent surface water, except for three, less than five-acre constructed reservoirs, located in developed areas with no potential for wildland fire spread. There are no natural, permanent streams, ponds, lakes, or riparian ecosystems in the park. There are several anchialine pools near the coast. These have been identified as wetlands in a cursory wetlands inventory conducted in the park. There are less than 10 very small patches of sedge dominated communities with frequent standing water, which might be considered to be wetlands. These probably total less than one acre and are scattered throughout the `Ola`a rain forest. There are a number of possible wetlands of similar size in the Kahuku Unit above the Hawai`i State Ka`u and Kapapala Forest Reserves. Fire potential is low in wetlands because they are located in areas without extensive or continuous fuels and the areas are not subject to wildland fire.

Wilderness

Approximately 131,540 acres of the park's 333,000 acres are designated wilderness, distributed in four disjunct units: the Mauna Loa Unit (58,589 acres) on the southwest facing slope and summit of Mauna Loa above 5,000 feet in elevation; the Ka`u Desert Unit (57,038 acres), encompassing the Ka`u Desert below 3,000 feet elevation; the `Ola`a Unit (9,329 acres) including the `Ola`a rain forest; and the East Rift Unit (6,584 acres) in the upper East Rift Zone. Although the Mauna Loa and Ka`u units contain extensive lava flows, there are fuels and fire potential in all four wilderness units. The Mauna Loa unit is located in the Alpine, Subalpine, and Montane Seasonal Fire Management Units. The Ka`u Desert unit is located in the Mid-Elevation Seasonal and Coastal Lowland Fire Management Units. The `Ola`a and East Rift units are in the Mesic/Wet Forest Fire Management Unit.

The Kahuku Unit, added to the park in 2003, has not yet been evaluated for wilderness designation. Areas within the Kahuku Unit that are recommended as eligible for wilderness designation will be treated as wilderness.

Soundscape

Natural soundscapes are in the process of being defined for the park. The different climate patterns and vegetation account for ecological gradients in the park and also control different natural sound environments. The nine acoustical zones and their dominant, distinguishing natural sounds have been tentatively identified in a draft soundscape plan and data is currently being analyzed. These include the following areas:

Shoreline. Surf and wave action dominate the sound of this zone, along with shorebirds and seabirds, and strong trade winds blowing across tall coastal bluffs and low shoreline vegetation.

Coastal Lowlands. Strong trade winds, especially with orographic uplift at the tops of the pali, dominate the sound of this zone.

Ka`u Desert/Kilauea Summit. The dominant sounds are strong trade winds blowing over the rough volcanic landscape.

`Ola`a Rain Forest. The dominant natural sounds are rain on the tree fern canopy and crickets, with localized occurrences of bird vocalizations.

Mauna Loa Forest. Bird vocalizations in forested areas are prominent.

Dry `Ohi`a Woodlands. The dominant sounds are strong trade winds in the forest canopy.

Mauna Loa Alpine. The dominant sounds are winds flowing over rough textured lava fields and occasional birds in the lower reaches of the zone.

Young Rain Forest. Rain on vegetation is a dominant sound along with high densities of birds in closed canopy forest, especially at higher elevations.

New Lava Flows. Sounds on the active flows include bench collapses; rock fall from cinder cones and pit crater edges; crackling of cooling pahoehoe flows; and the sounds of clinkers falling in moving `a`a flows, gas venting, methane explosions, and falling trees on the edge of lava flows.

Wildland/Urban Interface

The wildland/urban interface with the greatest fire potential is located on the boundary with the 375-acre Volcano Golf Course Subdivision. This subdivision is located immediately east of the park on the northern flank of Kilauea volcano. Just north of the subdivision are Keauhou Ranch buildings, owned by Kamehameha Schools Bishop Estate, and the San Diego Zoo’s Keauhou Bird Conservation Facility. The subdivision is a mixture of homes and undeveloped land with new houses continuing to be built.

Grass fuels, brush, and introduced trees in developed and undeveloped lots provide an abundant and nearly continuous fuel bed in the subdivision. Grass and brush fuels are also abundant on park lands and the developed portions of the ranch that are adjacent to the subdivision. Fire can carry between the subdivision, ranch, and the park. Fire use (natural fire) is not proposed for this area and prescribed fire would not be allowed in this part of the Mid-Elevation Seasonal Fire Management Unit.

There may be potential for localized fire spread from park wildlands into two large historic districts, Kilauea Military Camp, a 150-acre enclave in the park that is in the northern part of the Kilauea summit, and the park housing/administrative area, also at the summit. Grassy fuels grow up to the edge of the military camp; uluhe fern grows on the margins and interior of some portions of the park housing/administrative area. Fire use and prescribed fire are not proposed for this area.

With the Kahuku Unit, the park's wildland/urban interface has expanded. Extensive, sparsely vegetated lava flows are located between the Kahuku pastures and the lower elevations of the Ocean View, which reduce the chances of fire carrying between the park and Ocean View in this area. However, fuels are continuous between the park and the Nature Conservancy lands, private ranchlands, state Natural Area Reserves, and the upper elevations of the Ocean View. Fire may also carry between the lower Kahuku pastures and properties along Lorenzo Road, to the east of the park. Fire use and prescribed fire are not proposed for the Kahuku Pasture Fire Management Unit.

Vegetation, Wildlife, Native Ecosystems

Although the Hawaiian Islands have a relatively simple flora and fauna, they contain a great diversity of ecosystems or ecological zones and therefore fire environments. The diversity of ecosystems/fire environments is a result of steep rainfall and elevational gradients in the park. The windward side of the park receives nearly daily trade winds and rainfall of over 140 inches per year. The leeward portions of the park receive as little as 20 inches of rain. Elevation varies from sea level to nearly 14,000 feet. Environments range from tropical rain forest to desert scrub and from coastal strand to alpine scrub. The diversity of different aged lava flows is also responsible for ecosystem diversity. Younger, early successional communities and older successional communities lie side by side in each environmental zone.

The resulting ecological zones make up the park's seven Fire Management Units (FMUs). Each FMU is broadly consistent in vegetation, fuels, fire history, fire impacts, and resources at risk.

Alpine and Aeolian Fire Environment/Alpine Fire Management Unit (FMU-1)

Geography and Climate. The park's Alpine FMU extends from approximately 8,500 foot elevation to the summit of Mauna Loa at 13,677 foot elevation. Lying above the inversion layer, the climate is cool and dry. The annual rainfall is 20-28 inches. One or two light snows, typically melting within a few days, occur in the winter. The mean air temperature is 43-48 degrees Fahrenheit with frequent nightly frost in the winter

months. The alpine zone is found on the Mauna Loa Strip and in much of the Kahuku Unit.

Vegetation, Fuels, and Fire Potential. There is essentially no fire potential or resources at risk from fire in the Alpine FMU. Fuels and vegetation are sparse and low, consisting of small patches of stunted native shrubs, mostly pukiawe and `ohelo. Grasses, sedges, lichens, and mosses comprise the rest of the plant life. Most of the alpine zone consists of nearly barren lava flows.

Fire History. No fires have been documented in the alpine zone.

Management strategies. Under the current Fire Management Plan all wildland fire is excluded from the Alpine FMU. Other resource management activities are having a profound effect on alpine ecosystems. Ungulates have been excluded from the lower portion of the alpine zone of the Mauna Loa Strip through fencing and animal removal. Ungulate control is planned for Kahuku alpine areas. Control of incipient alien plant species is undertaken to protect alpine areas from fountain grass, mullein, and other species. All of the Mauna Loa Strip alpine is designated wilderness with two historic cabins and three summit trails. Kahuku alpine is remote and trailless and may be studied as potential wilderness.

Subalpine Fire Environment/Fire Management Unit (FMU-2).

Geography and Climate. The Subalpine FMU in Hawai`i Volcanoes National Park lies mauka of the forests on Mauna Loa and extends from approximately 6,500 foot elevation to 8,500 foot elevation or higher. The average annual temperature ranges from 40 to 50 degrees Fahrenheit, with occasional winter frost. On the Mauna Loa Strip, rainfall is from 30-40 inches per year. Summers are dry and most precipitation is in the winter. Additional precipitation is provided by fog-drip from trees and shrubs resulting from low-lying clouds. The climate of the Kahuku Subalpine Fire Management Unit is decidedly more moist, with nearly daily cloud cover and light precipitation on the southeast slope mauka of the Ka`u and Kapapala Forest Reserves. Dry periods with little or no rain can occur any time of year, resulting in a year-round fire season.

Vegetation, Fuels, and Fire Potential. Most of the park's Subalpine Fire Management Unit is in the Kahuku Unit. On the Mauna Loa Strip, much of the subalpine vegetation is concentrated in two major kipuka on older pahoehoe lava flows. Vegetation on the extensive, younger `a`a flows consists of scattered and very scattered native `ohi`a trees and native shrubs. Vegetation on the older pahoehoe is `ohi`a/ mamane woodland with an understory of open native shrubs and grasses. The most abundant native shrubs are `ohelo, pukiawe, and `a`ali`i. The most abundant grass is the native bunch grass, hair grass. Vegetation is similar in the Kahuku Unit but species diversity is not as developed because of four decades of browsing by mouflon sheep.

The potential for large or intense fires in the subalpine is low. Patches of vegetation with closely spaced shrubs and grasses are small and discontinuous. Vegetation is

sparse and low growing, with low fuel loadings. Young lava flows dissect subalpine fuel beds. Fire potential may increase in the subalpine in the Kahuku Unit with the removal of mouflon sheep by park control efforts. Once mouflon sheep are controlled, native vegetation will recover, including pukiawe and `ohelo, as well as native hair grass. Invasive grasses, such as velvet grass and sweet vernal grass, may increase in abundance and increase fire potential. However, the climate of the Kahuku Unit is subject to more frequent clouds, fog, and moisture than the Mauna Loa Strip. This may decrease fire potential.

Fire History. No fires have been documented in the subalpine zone on the Mauna Loa Strip; the fire history of the Kahuku Unit is unknown. Charcoal layers are present in the subalpine zone on the Mauna Loa Strip. These may reflect a period of fire incidents with more continuous vegetation prior to soil and vegetation loss due to cattle and feral goats.

Fire Effects. The effects of fire in the Subalpine FMU are not known because of the absence of recent fire in the park in this ecological zone. The response of the most common plants in the subalpine can be expected to be similar to their response in the montane seasonal zone. The scattered `ohi`a trees will be readily top killed but some may resprout. `A`ali`i and `ohelo, two common shrubs, will regenerate well after fire, as will native hairgrass. The other common shrub, pukiawe, will recovery poorly after fire. Mamane and koa, found in the lower part of the subalpine on the Mauna Loa Strip, will resprout or become established by seed after fire. The most abundant invasive grasses, velvet grass and sweet vernal grass, may increase in abundance after fire.

Resources at Risk. The subalpine, on the whole is remarkable for the high proportion of native plants and animals that make up the biotic community and the paucity of alien species. The Subalpine Fire Management Unit lies above the mosquito breeding habitat. Therefore, avian diseases transmitted by mosquitoes are not important limiting factors for the relatively abundant native bird life, including `Apapane, `Amakihi, `I`iwi, and `Oma`o. Feral goats, pigs, and mouflon sheep have been eradicated from the Mauna Loa Strip subalpine. These species will be removed from the Kahuku subalpine. Removal will promote the recovery of native vegetation and increase plant and animal biodiversity. Alien plant invaders are relatively unimportant in the subalpine, although scattered patches of invasive grasses such as velvet grass and sweet vernal grass are present. Threatened and endangered plant species include laukahi kuahiwi, Mauna Loa silversword, *Asplenium fragile*, and Hawaiian catchfly. Species of special concern include the rare plant Hawaiian strawberry, yellow eyed grass, and heau. Fire sensitivity of these rare plant species has not been determined.

Management strategies. Under the current Fire Management Plan all fire is excluded. Ungulates have been excluded from the subalpine zone of Mauna Loa Strip through fencing and animal removal. Ungulate control is planned for Kahuku subalpine areas and fencing and animal control has been started. Control of incipient alien plant species is being undertaken to protect subalpine areas from fountain grass and mullein. Endangered or rare plant species such as Mauna Loa silversword are outplanted. All of

the Mauna Loa Strip subalpine is designated wilderness and is penetrated by two trails. The Kahuku subalpine is remote with one primitive road and no trails and may be studied as potential wilderness.

Mesic/Wet Forest Fire Environment/Fire Management Unit (FMU-3)

The Mesic/Wet Forest Fire Management Unit includes all of the wet forest and most of the mesic forest of the park. Mesic and wet forest grade into each other along the sharp rainfall gradients that characterize the park. Mesic and wet forests also share many of the same species, fuels, and responses to fire. For these reasons, they are considered as one fire environment.

Mesic Forest

Geography and Climate. Mesic forests are found primarily east of Chain of Craters Road and west of wet forests; makai of wet forest in the southeastern section of the park; and in Kahuku mauka of the Ka`u and Kapapala Forest Reserves. Mesic forests receive approximately 60-90 inches of rain per year and range broadly between 2,000 to 6,500 feet in elevation.

Vegetation, Fuels, and Fire Potential. Mesic forests are dominated by closed to open stands of `ohi`a. The understory vegetation and fuels are highly variable. In Kahuku, mesic forest has an understory of tree ferns and native trees or native shrubs. East of Chain of Craters Road, the understory is similar but many areas are occupied by dense stands of introduced faya tree or uluhe fern. The understory of mesic forest in the lower East Rift of Kilauea is dominated by continuous swards of introduced swordfern that range 4-6 feet in height.

Fire History. Only the mesic forest stands in the lower East Rift have had a recent history of fire. Fire spread readily in older swordfern understory under windy conditions. Fire in a swordfern area consumes both green and dead fronds but leaves a thick litter and duff layer capable of burning immediately in subsequent fires.

Fire Effects. Swordfern vegetatively recovers very rapidly after fire, much more rapidly than native species. `Ohi`a appears to be regenerating in swordfern but many mesic forest trees, shrubs, and herbaceous understory elements are missing. Introduced faya tree and strawberry guava vegetatively recover very rapidly after fire.

Resources at Risk. Past wildfire and browsing by feral ungulates removed much of the diversity in mesic forest on Kilauea. Species of special concern remaining in the area include the trees, Papala ke pau and `Ohe mauka, and the endangered Hawaiian Hawk. Diversity of native plants and forest birds is much higher in the mesic environment of Kahuku. Inventories for endangered, threatened and rare species have not yet occurred in Kahuku.

Management strategy. Under the current and proposed Fire Management Plan strategy, all fires are suppressed to limit disturbance and invasion by alien species. Restoration strategies using direct seeding and outplanting into recent wildfire areas are being tested. Fire effects studies are underway to increase knowledge of fire effects in this environment. Only small portions of the mesic forest have been fenced for ungulate control or are managed for invasive species. There is very little visitor development and use, other than lightly used trails in the Crater Rim and East Rift areas.

Wet Forest

Geography and Climate. There are approximately 30,000 acres of tropical wet or rain forest in the park; it is much more widespread than mesic forest in the Mesic/Wet Forest Fire Management Unit. Almost all rain forest is found on the eastern edge of the park receiving nearly daily trade wind rains, resulting in approximately 90-140 or more inches per year. Rain forests are found in four locations: on the eastern rim of the summit caldera of Kilauea volcano; along the East Rift zone of Kilauea above approximately 2,300 foot elevation; in a 10,000 acre disjunct part of the park east of the community of Volcano, the `Ola`a Forest; and on the eastern edge of the pastures in Kahuku between 3,000 and 5,000 foot elevation.

Vegetation, Fuels, and Fire Potential. There are two major plant associations in the rain forest, one dominated by tree fern and one dominated by uluhe fern. The former association is a multi-layered forest dominated by `ohi`a and tree ferns. In many areas of Kilauea summit and the East Rift, `ohi`a forms closed stands on the relatively young substrates of these volcanically active areas, with a subcanopy of other native trees and tree ferns. Tree fern rain forest is best developed on the older, deep ash soils of `Ola`a Forest and some areas of the East Rift, particularly on older flows near Napau Crater. Most of the rain forest in `Ola`a is dominated by a dense canopy of tree fern, often co-mingled or slightly overtopped by open stands of native trees. `Ohi`a formed a nearly continuous overstory until a dieback in the late 1960s and early 1970s and now persists as scattered trees or occasional open stands. A high diversity of native ferns, often along with native shrubs and herbaceous plants, form a dense ground cover understory. Feral pigs have been removed from well over half of the park's rain forests and recovery of understory ferns, tree ferns, native shrubs, and native tree seedlings is taking place.

The other rain forest community relevant to fire management is dominated by uluhe fern, found at the summit of Kilauea and along the East Rift. Uluhe is a dense matted fern that forms a natural ladder fuel 3-20 feet tall, clambering over trees and shrubs. Because the thick mat suppresses all vegetation, native and alien, uluhe rain forest is less diverse than tree fern rain forest. Uluhe is characteristic of early successional communities on younger lava flows in the East Rift. It has also become more abundant on the East Rift southwest of Pu`u `O`o in recent years because it colonizes tephra deposits laid down in the 1983-1986 fountaining eruptions. It is the dominant fuel in the upper East Rift. Uluhe is also abundant in older forest stands, which have gone through a cycle of `Ohi`a dieback and recovery.

The lower fronds of uluhe fern retain dead foliage and a mat of fallen fronds form a continuous litter layer. Because the tree canopy is typically sparse, the understory and litter layer can dry out after a couple of weeks of little or no rain. Most uluhe fires have occurred after several weeks of no rain when uluhe litter dries out. However, during 2002, the Kupukupu Fire, a large fire on the East Rift, occurred under very windy conditions after just a week long drying trend following a rainy spring. In 2003 the Luhi Fire spread in uluhe during a period of extremely low relative humidity, following a wet spring, with low to moderate wind conditions.

Fire History. Until recently, lava caused fires have not been observed to carry into tree fern rain forest, even under drought conditions. In the 2003 Luhi Fire on the East Rift, fire flanked over 50 yards into dense tree fern stands, under record low humidity conditions, before dying out. Fire spread in continuous abundant litter of dead tree fern fronds and `ohi`a. No fires have been documented in tree fern rain forests in `Ola`a or the Kilauea summit.

On the East Rift, the first large fire documented in uluhe was the Valentine's Day Fire of 1996, which burned 600 acres, carried by uluhe and sword fern. Subsequent lava-ignited large fires occurred in 2002 (Kupukupu Fire) and in 2003 (Luhi Fire).

Because of these fires, a new fuel type has developed on the East Rift in burned areas. The bottom portion of the fuel bed was wet when the flaming front passed through. This left a 6 inch to two feet deep duff and litter layer capable of reburning one or more times. Because uluhe takes several years to recover, this litter fuel type is expected to persist in the rain forest for the near term.

Fire effects. Plant recovery after fire in uluhe varies by site. Uluhe, along with other native rain forest species, has been observed to recover to near preburn cover and abundance 10-15 years after fire (Tunison *et al*. 2001). Although alien grasses initially invade burned uluhe dominated forest, native grasses, sedges, and shrubs then get established, and uluhe recovers beginning two to three years after fire. Many native woody plants resprout, including tree ferns and `ohi`a. Others become established from seed. In other burned uluhe areas, aggressive alien plants invade immediate after fire and recovery of native plant species does not occur.

Resources at Risk. Late successional tree fern rain forest is species-rich. Most of the biological diversity in the rain forest is located in the ground cover layer, rather than in the canopies as in continental rain forests. Fern species account for much of the plant diversity. In `Ola`a, a third of the vascular plant species are ferns and fern allies. Although not rich in bird life, the native birds `Apapane and `Oma`o can be very abundant, especially where the `ohi`a canopy is dense. Insect life is rich in the rain forest. Significant species include Happyface Spider, two species of predaceous caterpillars, and a number of picture wing *Drosophila*. Threatened, endangered, and candidate species, as well as species of special concern, include the plants hi`awale, `ohawai, kihi, `anunu, `aku, `ohe, *Phyllostegia floribunda*, `awapuhi a kanaloa, and koli`i.

Management strategy. Under the current Fire Management Plan, all fires are suppressed to limit disturbance and invasion by alien species. Fire effects studies are underway to increase knowledge of fire effects in this environment. Portions of the rain forest have been fenced to exclude feral pigs in `Ola`a, Kilauea summit, and East Rift, and systematic alien plant control is underway in nearly half of these areas. Outplantings of endangered or rare plant species are undertaken in `Ola`a rain forest. The primary visitor use zone of the park is in the Kilauea summit rain forest along Crater Rim Drive. Rain forest areas in `Ola`a are trailless designated wilderness and the East Rift rain forest has a single trail and backcounry camp.

Montane Seasonal Fire Environment/Fire Management Unit (FMU-4)

Geography, Climate, and Geology. Most of the Montane Seasonal Fire Management Unit in the park lies on the lower slopes of Mauna Loa Strip mauka of mid-elevation seasonal woodland at 4,000-foot elevation and makai of the subalpine environment at 6,700-foot elevation. In Kahuku, the area between the 5,000-6,000 foot elevation on the southwest-facing slope between Manuka and Kipahoehoe Natural Area Reserves can also be characterized as montane seasonal.

The montane seasonal zone of the Mauna Loa Strip has a summer-dry climate with rainfall declining from 60 inches per year at 4,000 foot elevation to 40 inches per year at 6,000 foot elevation. The montane seasonal zone in Kahuku is summer-wet. Mean annual temperatures are 50-60 degrees Fahrenheit with occasional winter frost at higher elevations. Frequent afternoon cloud build up and low-lying fog are characteristic of the montane seasonal forests in Kahuku.

Vegetation, Fuels, and Fire Potential. Most of the montane seasonal zone on the Mauna Loa Strip is densely vegetated on 750-4,000 year old lava flows, although several massive, late prehistoric or historic `a`a flows penetrate the montane seasonal zone. Soil development is greatest in the lower portion of the zone at Kipuka Ki and Kipuka Puaulu between 4,000 and 4,400 foot elevation. These greater than 10,000-year-old kipuka have layers of ash soil up to 20 foot deep originating from the nearby Kilauea summit. Most soils above 5,000 foot elevation are shallow and discontinuous ash deposits over weathered pahoehoe.

The vegetation of the montane seasonal zone on the Mauna Loa Strip varies considerably with soil depth and substrate age. The most diverse and well-developed forests of the montane seasonal zone are in Kipuka Ki and Kipuka Puaulu on the lower east end of the Mauna Loa Strip (4,000-4,400 ft elevation). These islands of old soil support a rare manele/koa/`ohi`a forest community including many threatened, endangered, candidate or species of special concern including hau kuahiwi, koki`o, alani, `aiea, holei, `anunu, kilioe, `akala, manele, and kauila. Kipuka Puaulu is the most biologically rich site in the park.

On the Mauna Loa Strip, koa dominates the forests upslope on weathered pahoehoe above Kipuka Ki. Below 5,000-foot elevation, the understories of these forests are

dominated by alien pasture grasses, a legacy of 150 years of cattle grazing. Koa forest understory above 5,000 foot elevation is comprised of the native shrubs pukiawe and `a`ali`i, as well as native sedges and a mixture of alien meadowrice grass and native grasses.

Koa stands have rapidly expanded by root suckering into grasslands and shrublands on Mauna Loa since the mid-1970s when ungulates were removed from the area. Koa seedlings and suckers are highly palatable to cattle and feral goats. Grazing occurred under previous land owners, as a result of territorial and National Park Service agreements, and under marshall law in World War II. Grazing was terminated in 1948, but the remaining stray cattle and feral goats were not removed from Mauna Loa until the mid 1970s.

Small stands of shrubland and grassland persist on sites with shallow soils. The shrublands are dominated by the native shrubs pukiawe and `a`ali`i, with a continuous understory of mixed alien and native grasses at lower elevations and native bunchgrass above 5,000 foot elevation. Grasslands are generally small and are dominated by alien grasses at lower elevation and native bunch grasses at upper elevation.

`A`a flows are much more sparsely vegetated than older pahoehoe flows. In a number of places there is open to sparse `ohi`a woodlands with a sparse native shrub understory. In other areas, very scattered native shrubs may occur. Grass is never abundant.

Vegetation in the montane seasonal zone in Kahuku is dominated by closed stands of `ohi`a forest with a native shrub, fern, and mixed native-alien grass understory capable of carrying fire. Small stands of koa with invasive grass understory occur in the `ohi`a forest stands. A fire carried through one of these koa-`ohi`a stands in 1993. Native `ohi`a regenerated well by sprouting; koa did not recover because of mouflon sheep browsing; alien grasses became abundant.

On the Mauna Loa Strip, fuels are continuous in the forests, woodlands, shrublands, and grasslands on older pahoehoe. Vegetation below the 5,000-foot elevation is particularly dense and grass fuel loadings are high in all plant communities. The Mauna Loa Strip lies above the temperature inversion and is not subject to daily trade wind showers. Although summers tend to be drier than other seasons, extended dry periods can occur throughout the year. Curing (drying out of grasses and other fine fuels) and green up of the grass fuels can take place several times in a year and is timed to rain fall patterns that vary from year to year. Therefore, the Mauna Loa Strip montane seasonal zone has essentially a year-round fire season.

In Kahuku, forests and woodlands have been subjected to four decades of browsing by mouflon sheep and understory vegetation is relatively sparse. These factors suggest that fire potential of the Montane Seasonal FMU in Kahuku is lower than that of the Mauna Loa Strip. Removal of the sheep in the near future may increase fuel loadings of

grasses and woody vegetation. The fire potential of the montane seasonal zone in Kahuku may increase.

Fire History. There were a number of small, human-caused ignitions in the 1920-40s while the Mauna Loa Strip was leased for cattle ranching. There was a 2,000 acre fire in 1975 in koa forest, shrublands, and grasslands. In spite of abundant fuels on the Mauna Loa Strip, there have been no fires since then. Part of this may be due to vigorous fire prevention, closing the Mauna Loa Road in very high and extreme fire danger. In addition, the infrequent lava flows from Mauna Loa have been well distant from the park. Continued cattle ranching has reduced grass fuel loadings and human access in lands adjoining the park. The fire history of Kahuku is not known in detail. A wildfire starting in ranchlands below what is now the Kahuku Unit of the park penetrated a stand of `ohi`a and koa in 1993.

Unlike many other environments in the park, fire may have played an important role in the evolution of the montane seasonal ecosystems (Mueller-Dombois 1981). This is suggested by the fact that there are continuous fine fuels in the form of native grasses and shrubs and that many of the dominant plant species, including koa, `a`ali`i, and native grasses recover rapidly from fire by resprouting or seed. On the other hand, the montane seasonal communities are at a highly dynamic stage of development. The suite of species on the Mauna Loa Strip that responded positively to release from herbivores may share characteristics common to fire-adapted species, but may not be fire adapted or fire adapted by virtue of those characteristics.

Fire Effects. On the Mauna Loa Strip, the major impact of fire in koa forest with invasive grass understory is to alter the stand structure of koa forest, replacing older, larger diameter trees with small stems. Koa resprouts readily from root suckers after fire to reestablish the forest overstory within a decade. The potential nesting and foraging habitat for rare forest birds declines with the loss of larger, old growth koa. Younger trees provide excellent habitat to Elepaio and the endangered `Akiapola`au. Alien meadowrice grass, the dominant understory component, rapidly recovers. Shrublands and grasslands change only subtly in composition after fire, with a shift in cover from less fire-tolerant pukiawe to the more fire-tolerant `a`ali`i, with no net increase in alien species cover, including alien grasses.

These observations about fire in the Montane Seasonal Fire Management Unit are based on succession following the only fire to occur on the Mauna Loa Strip in the last 30 years (Hauss unpubl.). New alien species have since become established in the park and vicinity since that fire and others have increased in abundance. These newly arrived species may affect succession after future fires. Historical fire is not known from the unique, species-rich Kipuka Ki and Kipuka Puaulu. The fire tolerance of the many woody species in these kipuka, including the numerous rare species, is not known.

There was a large fire in Kahuku in `ohi`a/koa forest in 1993. Recovery of koa and other species has been inhibited by browsing of mouflon sheep. `Ohi`a and naio, plants ignored by sheep, are recovering rapidly after fire by resprouting.

Resources at Risk. The greatest diversity and concentration of rare plants in the park is in manele/koa/`ohi`a forest in Kipuka Ki and Kipuka Puaulu. These include many threatened and endangered plant species and candidate or species of special concern including hau kuahiwi, koki`o, alani, `aiea, holei, `anunu, kilioe, `akala, manele, `a`e, `olona, and kauila. Kipanapona, an endangered Hawaiian mint, is present at higher elevations on the Mauna Loa strip. Rare plants in the Montane Seasonal Fire Management Unit of Kahuku have not been inventoried.

The Montane Seasonal Fire Management Unit (as well as the lower portions of the subalpine) supports the greatest densities of native birds of any of the park's major ecological zones. The widespread `Apapane and `Amakihi are particularly abundant. `I`iwi and `Elepaio also occur in high numbers. The montane seasonal zone was the former habitat of three endangered bird species that were lost from the park in the last half century: `Akiapola`au, Hawai`i creeper, and `Akepa. The recovery of woodlands and forest on Mauna Loa following the removal of cattle and goats may eventually provide suitable habitat to support these species, either through natural migration or deliberate translocation.

The uplands are notable for many endemic insect species such as the two native butterflies of Hawai`i, the Kamehameha butterfly and the Blackburn butterfly and a broad diversity of native long horned beetles. Kipuka Ki and Kipuka Puaulu are habitat for many native insect species, including two species of the large, picture wing *Drosophila* flies endemic largely to these sites: *Drosophila engrochracea* and *Drosophila mimica,* which require soapberry bark and fruit to carry out their life cycles.

Management strategies. The current Fire Management Plan strategy is to exclude fire. The montane seasonal zone on the Mauna Loa Strip is fenced and free of introduced ungulates. Alien plant control is underway for control of localized populations of mullein and faya tree. Outplantings of endangered or rare plant species such as Mauna Loa silversword are undertaken. Restoration of koa forest understory is underway in several sites, with control of invasive weed species and outplanting and direct seeding of native species. Intensive outplanting of endangered and rare plant species is underway in Kipuka Ki and Kipuka Puaulu. Visitor use and development is primarily centered on the lightly used Mauna Loa Road, an interpretive trail in Kipuka Puaulu, the Mauna Loa Observatory Shelter, and the Mauna Loa Trail. Management of the Kahuku montane seasonal zone has begun by constructing fence and controlling sheep and goats.

Mid-elevation Seasonal Fire Environment/Fire Management Unit (FMU-5)

Geography, Climate, and Geology. The mid-elevation seasonal woodland zone is the area of the park above Hilina, Poliokeawe, and Holei Pali and below, west, and south of Kilauea Caldera. The upper elevation is approximately 4,000 foot elevation and the lower elevation varies from 1,000 to 2,000 foot elevation. The mid-elevation seasonal woodland zone also occurs in Kahuku west of the pastures from 2,500 to 4,500 foot elevation. The mid-elevation seasonal zone is in the leeward part of the park sheltered

from daily trade-wind rains. Rainfall varies from 20-60 inches per year, and there is typically a distinct summer dry period. Dry periods on the island can result in pronounced drought in lower portions of the mid-elevation seasonal zone.

Vegetation, Fuels, and Fire Potential. Vegetation of the Mid-Elevation Seasonal Fire Management Unit varies with substrate and rainfall. On younger flows or deep cinder with little ash soil development, vegetation typically consists of sparse native shrubs, primarily pukiawe and `a`ali`i, and scattered, short-statured `ohi`a. Fire potential of these communities is very low. Flows with deeper ash support dry `ohi`a woodland. Undisturbed, this community is characterized by open stands of `ohi`a and native shrubs, and a sparse ground layer of native sedge, lichens, and mosses. However, this plant community is one of the most disturbed and altered in the park. The understory, invaded by alien grasses in the 1960s, is now dominated by beardgrass, broomsedge, and molasses grass. These alien grasses form a nearly continuous matrix between the open layer of native shrubs. The majority of dry `ohi`a woodlands have burned in the last 30 years, further degrading this community to savannas of scattered `ohi`a with scattered native shrubs and abundant alien grass. Other areas have been invaded by the alien faya tree which has become a co-dominant with `ohi`a in some areas and displaced `ohi`a in other areas. In portions of the dry `ohi`a woodland along Hilina Pali Road, the two-spotted leafhopper has caused an extensive dieback of both faya tree and `ohi`a.

The Mid-Elevation Seasonal Fire Management Unit in Kahuku also supports dry `ohi`a woodland degraded by invasive grasses, including beardgrass, broomsedge, and barbwire grass. The invasive shrub Christmasberry is also invading these woodland stands. `Ohi`a is slowly reestablishing in fallow pastures. Dry `ohi`a woodland in Kahuku occurs in the dry, western portion of the pasture zone in abandoned pastures.

Fire History. Anthropogenic burning by prehistoric Native Hawaiians occurred in Hawaiian coastal lowlands (Kirch 1982). Although an analysis of prehistoric anthropogenic fire use has not occurred for the park, it is believed that burning practices modified the coastal lowlands below 500 foot elevation and may have affected lower portions of the dry `ohi`a woodlands up to 1,500 foot elevation. Moving into the modern era, wildland fire (naturally ignited fire) has been most prevalent in the park in the Mid-Elevation Seasonal Fire Management Unit. Following the invasion of broomsedge and beardgrass in the mid 1960s, and molasses grass in the 1980s, the area burned per year increased almost 2,000 fold and the number of fires increased nearly 10-fold (Tunison *et. al.* 1995). Nearly two-thirds of the burnable area of the Mid-Elevation Seasonal Fire Management Unit burned in the last 40 years. Evidence of a fire is apparent in the Mid-Elevation Seasonal Fire Management Unit in Kahuku but the details about this fire are not known.

Fire Effects. Fire has been highly destructive to native ecosystems in the Mid-Elevation Seasonal Fire Management Unit. Fire greatly reduces native woody vegetation, especially the community dominants, `ohi`a and pukiawe. On average, 55% of the `ohi`a are killed by fire (D'Antonio *et al*. 2000). Some surviving trees that were partially

protected from fire were on pahoehoe tumuli that had little alien grass fuel. More typically, aerial portions of the trees were killed and surviving individuals recovered by crown or epicormic sprouts (sprouts originating along trunks and branches) (Parman and Wampler 1976, Tunison *et al*. 1995). `Ohi`a seedlings do not become established to replace `ohi`a trees killed by fire. In fact, `ohi`a seedlings were not found in any recently burned seasonally dry woodlands (Tunison *et al*. 1995). The loss of mature `ohi`a and failure of `ohi`a to recruit from seed resulted in the conversion of open canopied woodlands to savannas characterized by scattered to very scattered trees.

Three of the four native shrub species (pukiawe, `ulei, and `akia) common in the mid-elevation seasonal zone before fire were sharply reduced in cover and density following fire, and show little sign of recovery, even 17 years after fire (Hughes *et al*. 1991, Tunison *et al*. 1995). The aerial portions of all four shrubs (`a`ali`i and the three previously mentioned) are readily killed by fire, although resprouting occasionally took place under low fire intensity conditions (Tunison *et al*. 1995). Native shrub cover, as a whole, is reduced by nearly two orders of magnitude. Pukiawe, the dominant shrub before fire, is nearly absent in most burned areas; it declined 10-fold in cover and 3-fold in density after fire. Although mature plants of the common shrub, `a`ali`i, were killed by fire, this native shrub species generally recovered to pre-fire abundance. Recruitment from seed was substantial (Hughes *et al*. 1991). Recruitment into larger size classes occurred through dense grass cover and densities of large plants were similar in older burns to densities in unburned areas (D'Antonio *et al*. 2000). Although sample sizes were very small, the small native tree mamane resprouted nearly invariably from the root crown, even after severe fires (Tunison *et al*. 1995).

Alien grass cover increases on average by one-third after fire (D'Antonio *et al*. 2000, Tunison *et al*. 1995). Alien grass biomass increases 2-3-fold after fire, increasing fuel loadings. Molasses grass cover increases the most in burned sites in which it was present prior to fire.

The rapid reestablishment and long-term persistence of alien grasses inhibit shrub colonization and growth (Hughes and Vitousek 1993). This was particularly true in sites in which molasses grass was present (D'Antonio *et al*. 2000); native shrub cover was lowest in these sites. The vigorous response of this mat-forming species creates a formidable environment for native species regeneration. The native shrub `a`ali`i persists in burned areas because of its rapid germination and growth.

The invasion of broomsedge and beardgrass into the seasonally dry woodland has established an alien grass/fire cycle (Hughes *et al*. 1991, D'Antonio and Vitousek 1992, Freifelder *et al*. 1998). Grass invasion of seasonally dry woodlands promotes fire in a previously fire-independent ecosystem and alters the disturbance regime of this ecosystem. After fire, grasses out-compete native woody plants and increase in cover and fuel loading (Hughes *et al.* 1991, D'Antonio *et al*. 2000). Burned sites are then predisposed to more severe future fire compared to adjacent unburned woodlands because of increased fuel loadings and, more importantly, because wind speeds are substantially greater in the more open post-fire savannas (Freifelder 1998).

Resources at Risk. At risk are remaining unburned stands of dry `ohi`a forest and woodland. These are habitat for declining populations of rare plant species including kauila, ko`oko`olau, hoawa, and the endangered `ohai.

*Management Strategie*s. Under the current Fire Management Plan, all wildland fires are suppressed. Prescribed fire has been used experimentally and has proven to be a useful tool in experimental rehabilitation of fire-damaged dry `ohi`a woodlands conducted between 1993-2000 (Loh unpubl.). Four small, prescribed burns have been conducted since 1993 to test methods for establishing fire-tolerant native plant species in burned areas in the mid-elevation seasonal environments. The species targeted for restoration are tolerant of fire, recovering rapidly from seed and/or resprouts. Many of these species were formerly more abundant, but populations were depleted by past feral goat browsing. Goats were removed from the park in the 1970s but natural recovery of species was poor because of insufficient seeds in the soil. Prescribed fire accompanied by direct seeding and outplanting results in successful establishment of fire-tolerant species. Prescribed fire temporarily removes the alien grass mats and allows establishment of seedlings from artificial seeding of the area. Grasses eventually recover, but seedlings are able to survive and grow to attain reproductive maturity. Past restoration with fire-tolerant species is limited to small experimental prescribed burns in isolated kipuka and following the occurrence of natural wildfires (Loh *et al*. 2003, Loh *et al*. in prep.). Under these conditions, areas with the greatest need or highest potential for native plant restoration were not necessarily included.

Coastal Lowland Fire Environment/Fire Management Unit (FMU-6)

Geography and Climate. The Coastal Lowland Fire Management Unit lies below the Mid-Elevation Seasonal Fire Management Unit. It includes the coastal strand along the immediate shoreline and the coastal plain makai of the large fault scarps or pali, usually located one to several miles away from the shoreline, and woodland communities on the face of the pali.

The Coastal Lowlands Fire Management Unit is typically warm and dry. Rainfall varies from about 60 inches per year in the eastern park boundary near Kalapana to less than 20 inches in the west. Summer drought conditions characterize the area.

Vegetation, Fuels, and Fire Potential. The combination of dry conditions and relatively young substrates limits the development of vegetation. A narrow band of coastal strand vegetation is found in a number of areas along the immediate shoreline. Vegetation varies from naupaka dominated scrub to sparse salt-tolerant herbs. The endangered grass *Ischaemum byrone*, the endangered loulu palm, and the species of special concern, *Portulaca villosa,* grows in a number of locations where outplanted. The endangered shrub `ohai grows in some coastal strand sites. Fire is generally not a major concern in the coastal strand, except for the upper fringe of the strand in some areas. Where grass fuels are present, they tend to be low growing and scattered.

The coastal plains of the park are now largely dominated by grasses. The wetter, eastern coastal lowlands have the remains of a coastal shrubland, modified by fire. Prior to fire this community was dominated by tall `akia shrubs, along with other native shrubs including `a`ali`i and `ulei. Alien broomsedge and beardgrass, along with native pili grass, formed a matrix between the shrubs and permitted wildfires to spread. Most of the `akia shrublands burned in the Pu`u `O`o eruptions that started in 1983. Small pockets persist. However, most of the `akia shrubland has been converted to low open shrubland with scattered `a`ali`i and `ulei, with broomsedge, beardgrass, and pili grass between the shrubs.

The western portion of the coastal lowlands are dominated by alien grasslands with patches of alien shrubs. The dominant grasses are alien Natal redtop, thatching grass, molasses grass, beardgrass, and broomsedge. Native pili grass is an important component of the grasslands in some areas. Wildfire has become relatively frequent in the coastal lowlands in the last 30 years. Feral goats were removed in the early 1970s. Without grazing pressure, the previously mentioned grass species replaced low growing grasses that were adapted to grazing pressure.

The coastal lowlands also contain small scattered stands of dry and mesic forests on the faces of the pali. Younger flows are dominated by open stands of `ohi`a. The short native tree lama with an understory of the shrub alahe`e replaces `ohi`a on older flows. A number of threatened, endangered, and candidate species include kauila, halapepe, `ahakea, and `ohe makai. Lama forests in the park have been greatly reduced in the last 30 years by lava flows so that just a few patches remain. Although grassy fuels are common only in the smaller lama forest patches, fire may carry in alien sword fern and lantana during extreme fire conditions. Lama recovers poorly after fire.

Fire History. Anthropogenic burning by prehistoric Native Hawaiians occurred in Hawaiian coastal lowlands (Kirch 1982). Fires were started to clear forest for agriculture and to stimulate the growth and abundance of pili grass, used as thatching material, and other favorable plants. Although an analysis of prehistoric coastal lowland anthropogenic fire use has not occurred for the park, it is believed that burning practices modified the coastal lowlands below 500 foot elevation and may have affected lower portions of the dry `ohi`a woodlands up to 1,500 foot elevation. By 1924, fire records indicate that fire was a very rare event in the coastal lowlands of the park. Broomsedge and beardgrass invaded the eastern coastal lowlands in the early 1960s. Wildland fire, ignited by lava flows, occurred in the early 1970-1990s. Feral goats were removed in the early 1970s from the central coastal lowlands. Tall, perennial, fire-promoting grasses quickly replaced annual and short perennial grasses. The removal of goats has also allowed the recovery of native pili grass in some areas of the coastal lowlands. As a result of the increased grass abundance, fires have occurred in the central coastal lowlands in the last 30 years.

Fire Effects. The impact of fire varied between the two major vegetation types in the Coastal Lowland Fire Management Unit (Tunison *et al*. 1994). In the shrublands in the eastern coastal lowlands, a matrix of broomsedge and beardgrass filled in the gaps in

open shrubland and carried the wildfires that occurred. Even though the fire-intolerant native shrub `akia was nearly eliminated by fire, other native shrubs, including `a`ali`i and uhaloa recovered rapidly from seed and the native shrub `ulei recovered by resprouting. There was a net increase in native plant cover because of a positive response of native pili grass to fire. In the central coastal lowlands, fire had little long-term effect on the composition of alien grasslands because the recovery to pre-fire composition and abundance was rapid. Fire also enhanced the cover of native pili grass in pili-Natal redtop communities.

Fire in the coastal lowlands was not as damaging to native ecosystems as it was in the seasonally dry woodland, even though alien, fire-promoting grasses had invaded this ecosystem (D'Antonio *et al*. 2000). Part of this favorable response can be attributed to the presence of shrub species that recover by resprouting or became established from seed. However, the favorable response is also partly due to the persistence of native pili grass that survived cattle, feral goats, and the spread of tropical and subtropical alien grasses after goat control. Pili is a fire-stimulated species and has a history of responding to fire in the lowlands. It was probably an important historical component of the coastal lowlands and Polynesians used fire in the coastal areas to stimulate pili.

Resources at Risk. Small patches of dry and mesic lama forest contain a number of rare, threatened, and endangered plant species (kauila, halapepe, `ohe). The endangered grass Ischaemum byrone, the endangered loulu palm, `ohai, and the species of special concern, *Portulaca villosa*, grow in the coastal strand. The endangered Nene goose is observed in the eastern portion of the coastal lowlands.

Management Strategies. Feral goats were removed from the coastal lowlands in the 1970s by a combination of fencing and animal control efforts. Limited manual and chemical treatments are currently in place to prevent the widespread establishment of fountain grass. Outside the park, fountain grass has increased fuel loads and consequently fire frequency and intensity in areas it invades. Fires carried by fountain grass have caused considerable damage to native lowland dry ecosystems and threatened urban areas on the west side of the island. In the park, fountain grass poses a unique problem because of the plants ability to thrive in harsh environments such as barren lava flows, poor soils, and xeric conditions not favorable to other alien grasses.

A systematic control program for fountain grass has been in place since the mid-1980s. Fountain grass occurs across 21,000 hectares in the park between sea level and 4,000 foot elevation (Tunison *et al.* 1994). Fortunately, it is distributed at very low densities for over 90% of its range. Park staff made an intensive effort to control satellite populations. This program has been successful in preventing expansion into new areas and reducing densities of core populations. Chemical control is used to initially knock down populations followed by manual retreatment to prevent re-establishment from seed until the seed bank is depleted.

Under the current Fire Management Plan, between 1995-2002, four prescribed burns were conducted to evaluate the efficacy of using prescribed burns to restore pili

grasslands. Once dominant on the dry lowland slopes of the Hawaiian islands, pili grasslands are much reduced and are mixed or replaced by introduced grasses and woody species on the island of Hawai`i. Two small prescribed burns conducted in mixed pili-alien grasslands show that pili abundance can increase relative to alien grasses present in the area, but results vary according to the alien species present (Loh unpubl.). A series of prescribed burns are currently underway to 1) determine whether pili grasslands can be maintained or expanded through the use of prescribed burns, 2) determine whether fire severity of subsequent fires is reduced by periodic burning, and 3) test the response of selected lowland native species to frequent fires.

Kahuku Pasture Fire Environment/Fire Management Unit (FMU-7)

Geography and Climate. The Kahuku Unit has brought a new fire Fire Management Unit into the park. There are approximately 7,200 acres of pasture extending from 2,500 foot elevation to 5,000 foot elevation on the south slope of Mauna Loa. The area extends east to mesic forest (60-80 inches of rain per year) and west to seasonally dry `ohi`a woodlands (40-60 inches of rain per year).

Vegetation, Fuels, and Fire Potential. Most of the pastures have an open canopy of `ohi`a or `ohi`a/koa with an understory of pasture grasses, predominantly Kikuyugrass. Small kipuka of diverse mesic forest are scattered on the east end of the pasture. Grazing has prevented the invasion of alien shrubs and tall-grasses found commonly in fallow, cleared land outside the park. Cattle grazing will continue until 2009 under a Special Use Permit to prevent the invasion of weedy grass and shrub species into the pastures and surrounding forest. Grazing may continue on a smaller scale after that and eventually be phased out as park staff reforests some pastures and allows others to naturally recover.

With intensive grazing, the risk of fire is low to moderate because fuel loadings of grasses are relatively low and dead grass biomass is not allowed to accumulate. Pastures, including those dominated by Kikuyugrass, are not invulnerable to fire. Grazed pastures are capable of carrying fire, as evident by the Six Tanks Fire of 1975. This fire started in Keauhou Ranch in pasture lands. It swept through the park and burned into privately held ranch lands that adjoin the park. The main fuel in the ranch lands was Kikuyugrass. Fire potential in the Kahuku pastures is probably greater at lower elevations and to the west where rainfall is lower. Nearly daily rains affect the pastures to the east and at higher elevations.

Fire potential will increase in the pastures with the phasing out of cattle grazing. Abandoned pastures on the drier, western side of the pasture zone are being invaded by fire-promoting grasses including beardgrass, broomsedge, and barbwire grass, as well as the invasive shrub Christmasberry. If left unmanaged, fuel loads may increase and eventually resemble areas in the Mid-Elevation Seasonal FMU in the older part of the park in the lee of Kilauea volcano where fire has been most prevalent.

The park will actively restore pastures to mixed koa and `ohi`a forests on the moister, eastern side of the pasture zone. Following cessation of cattle grazing, conversion from pasture to native forest will be accomplished through a combination of natural recovery and active restoration. Active restoration will include herbicidal removal of alien grasses to allow native woody plants to become established supplemented by native plant reintroduction in selected areas. Conversion of pastures to forests through natural recovery and active reforestation will reduce fire potential in the long term by eliminating grass fuels. However, in the early stages of recovery and restoration, there will be dense stands of young trees in a grassy matrix, a fuel type with high fire potential.

Fire History. The fire history of the grazing areas is not known

Fire Effects. The response of some of the more common plants can be expected to be similar to their response in nearby Mid-Elevation Seasonal and Montane Seasonal FMUs. `Ohi`a trees will be readily top killed but some may resprout. Koa will resprout or become established by seed after fire. Alien grasses will rapidly re-establish, particularly on the drier west end where fire-adapted beardgrass and broomsedge are invading pastures.

Resources at Risk. Numerous kipuka of native mesic forest are located on the east end of the Kahuku pasture zone. These kipuka serve as important seed sources for pasture reforestation. Kipuka also have the potential to contain rare, threatened, and endangered species. Biological surveys to identify potential resources at risk will begin in Fall 2004.

Management strategies. Management of this portion of the Kahuku Unit has just begun. Fire use and prescribed fire are not proposed for the Kahuku Pasture Fire Management Unit. Cattle grazing is being maintained in the short term to prevent the invasion of invasive grass and brush species and reduce fire potential. Plans for reforestation of the pastures are being developed. Manual and chemical treatment to limit the spread of invasive grasses that can increase fire potential are currently being planned.

Threatened and Endangered Species and Species of Special Concern

The flora and fauna of Hawai`i Volcanoes National Park contains a high proportion of threatened and endangered species, and species of special concern. There are 25 threatened and endangered plant species, or 7% of the park's native flowering plants and ferns (Table 2). There are 72 plant species of special concern. These include four candidate endangered species, 23 species of special concern, 5 former species of special concern, and 40 species deemed rare in the park by park botanists. Threatened and endangered species, as well as species of special concern, comprise one-quarter of the park's native flora of vascular plants.

Eight of the park's 12 resident vertebrates are threatened or endangered species (Table 2). These include `Ope`ape`a (Hawaiian Hoary Bat), Nene (Hawaiian goose), `Io (Hawaiian Hawk), `Ua`u (Hawaiian Petrel), `A`o (Newell's Shearwater), `Akepa, Hawai`i

Creeper, and Honuea (Hawksbill Turtle). Five of these species have habitat in fire-prone areas of the park. In addition, there are five candidate or proposed endangered animal species in the park.

Table 2. Threatened and Endangered Species, Hawai`i Volcanoes National Park.

SPECIES	COMMON NAME	ENVIRONMENT	RISK OF FIRE
PLANTS			
Adenophorus periens	Kihi	Rain forest	Low
Argyroxiphium kauense	Mauna Loa Silversword	Subalpine/ Alpine	Low
Arygyroxiphium sandwicense subsp. *macrocephalum*	Haleakala silversword	Subalpine/ Alpine	Low
Arygyroxiphium sandwicense subsp. *sandwicense*	Mauna Kea silversword	Subalpine/ Alpine	Low
Asplenium peruvianum var fragile	No common name	Subalpine/ Alpine	Low
Caesalpinia kavaiensis	Uhiuhi	Coastal lowlands	Moderate
Clermontia peleana subsp. peleana	`Oha wai	Rain forest	Low
Cyrtandra giffardii	Ha`iwale	Rain forest	Low
Cyrtandra tintinnabula	Ha`iwale	Rain forest	Low
Hibiscadelphus giffardianus	Hau kuahiwi	Montane seasonal	High
Ischaemum byrone	Hilo ischaemum	Coastal lowlands	Moderate
Kokia drynarioides	Koki`o	Montane seasonal/ Mid-elevation woodlands	High
Melicope zahlbruckneri	Alani	Montane-seasonal	High
Neraudia ovata	No common name	Montane seasonal	Moderate
Nothocestrum breviflorum	`Aiea	Montane seasonal	High
Ochrosia kilaueaensis	Holei	Montane seasonal	High
Phyllostegia racemosa	Kiponopona	Montane seasonal	High
Plantago hawaiensis	Lau kahi kuahiwi	Subalpine	Low
Pleomele hawaiiensis	Halapepe	Coastal lowlands	Moderate
Portulaca sclerocarpa	`Ihi makole	Mid-elevation woodlands	Low
Pritchardia affinis	Loulu	Coastal lowlands	Moderate
Sesbania tomentosa	`Ohai	Coastal lowlands	Moderate
Sicyos alba	`Anunu	Rain forest	Low
Silene hawaiiensis	Hawaiian catchfly	Montane seasonal	Low
Spermolepis hawaiiensis	No common name	Mid-elevation woodlands	Moderate
Zanthoxylum hawaiiense	A`e	Montane seasonal	High
ANIMALS			
Buteo solitarius	`Io	Widespread	Moderate
Eretmochelys imbricate	Hawksbill Turtle, Honuea	Coastal lowlands	Low
Nesochen sandvicensis	Nene, Hawaiian Goose	Widespread	Moderate; potentially benefiting from fire
Pterodroma phaeopygia sandwichensis	`Ua`u, Hawaiian Petrel	Subalpine/ Alpine	Low
Puffinis newelli	`A`o, Newell's Shearwater	Rain forest	Low
Oreomystis mana	Hawaii Creeper	Montane seasonal	Low
Lasiurus cinereus semotus	`Ope`ape`a, Hawaiian Hoary Bat	Montane seasonal	High
Loxops coccineus	`Akepa	Montane seasonal	Low

Caves

Extensive networks of lava tube caves underlie many areas of the park. Lave tubes originate when cooling crust forms over underlying molten lava streams. The crust insulates the moving lava, but eventually the sources of the flow cease and the tubes empty of molten material creating a cave. Caves contain a number of unique geological formations, as well as cultural, paleontological, and biological resources. Geological resources include stalactites, stalagmites, and unique mineral deposits. Caves were used extensively by Hawaiians for burials, shelter, water collection, and petroglyph making. The most protected, intact archeological features of the park may be in lava tube caves. Caves have been the source of many fossil bird findings in Hawai`i. There are a number of endemic, cave-adapted invertebrates and undoubtedly cave microorganisms in Hawaiian lava tubes. Cave ecosystems are supported by tree roots penetrating cracks and the cave openings, and organic slime materials leached from above. Lava tube openings often support rare vegetation protected from alien ungulates.

VISITOR USE AND EXPERIENCE

Hawai`i Volcanoes National Park has year-round visitation with peaks at Christmas, spring break, and summer. There are approximately 2.3 million recreational and non-recreational visitors per year. Approximately half of the park visitors arrive by private vehicle and half arrive on a commercial tour. Almost all visitation occurs along Crater Rim Drive and Chain of Craters Road. Hilina Pali and Mauna Loa Road are visited by 10-30 cars per day. Interim operation planning for the Kahuku Unit is underway and currently visitor access is limited. However, this is expected to change upon completion of the interim operational plan. `Ainahou Ranch receives limited public use by permit only; this use is generally for educational or resource management purposes.

Most park use is day-use. There are two small campgrounds in the park, one is near the Kilauea summit and the other is a walk-in campground on the Hilina Pali Road. There are less than 20 campsites altogether. `Ainahou Ranch has limited overnight use, by permit only. Day hiking is popular on the Crater Rim Trail and trails inside Kilauea Caldera. The backcountry and wilderness areas of the park are lightly used. Most use is concentrated at three small backcountry camps along the coast at Keauhou Landing, Halape, and Ka`aha. The trail to the summit of Mauna Loa is also used and there are rustic cabins at Red Hill and the summit for visitor and staff use. There were 6,398 overnight visits in the park backcountry in 2003. In addition, over 120,000 visitors per year experience the park on air tours, with the focus primarily on the active volcanic areas.

Visitation is primarily focused on viewing and understanding volcanic processes and activities. However, people visit the park for a number of reasons, including those interested in the park's cultural resources, those wishing to practice traditional cultural activities including plant collecting, and people wishing to experience the relative solitude of the park's backcountry. Visitors are attracted to the park's native

ecosystems for nature study, primarily in the mesic forests of Kipuka Puaulu or rain forests along the Crater Rim. Active lava flows, particularly when accessible, draw nearly all visitors. Finally, approximately 60 university and government researchers conduct geological or biological research in the park.

State Route (SR) 11 runs through the park. Designed as a part of the state highway system, its primary function is the movement of people around the island. Within the park, SR 11 has a number of pullouts that provide panoramic views. There are two roads within the park that receive the greatest amount of visitor use (not including SR 11); these are the Crater Rim Drive and the Chain of Craters Road. Crater Rim Drive is a scenic park drive located along the rim of Kilauea Caldera. It has a number of pullouts and many afford visitors panoramic views of the park. The Chain of Craters Road is a scenic 20 mile drive that extends from Crater Rim Drive down to the coast, ending where recent lava flows crossed the road. Along the 20 mile route there are a number of pullouts that provide panoramic views of the park.

There are two scenic, backcountry drives within the park, the Mauna Loa Strip Road and the Hilina Pali Road. Both roads provide visitors the opportunity to leave the more heavily visited areas of the park and travel on narrow, rustic roads into the park's backcountry. Both of these roads also serve as access points to backcountry trailheads for day and overnight users.

The Kilauea Visitor Center is located on Crater Rim Drive. The visitor center provides orientation for the park visitor through a number of exhibits about the park and through staff interaction with visitors. In addition to providing park orientation, the visitor center is where backcountry users register for their backcountry trips with visitor center staff.

Jaggar Museum is located on Crater Rim Drive and is adjacent to the Hawaiian Volcano Observatory, which is a U.S.G.S. research facility. Jaggar Museum has a number of exhibits that pertain to earth science and murals that depict Native Hawaiian culture.

The Volcano Art Center, located near the Kilauea Visitor Center, is a retail gallery for local artists and craftspeople. It presently operates under a cooperative agreement.

Other commercial services include a hotel, the Volcano House, with 42 rooms, two gift shops, a dining room, and a snack bar. The hotel is located on Crater Rim Drive, across the road from the Kilauea Visitor Center. The operator also rents out primitive cabins in the Namakani Campground, which is located in the park off of State Route 11. This operation is authorized under a concession contract.

Kilauea Military Camp is located on Crater Rim Drive, almost half way between the Kilauea Visitor Center and Jaggar Museum. The 49 acre camp is a U.S. Army recreational area for active and retired members of the Armed Forces and their families. It is authorized under a Special Use Permit.

The visitor center and museum are key places for visitors to receive information on changing visitor use conditions in the park associated with conditions such as wildland or prescribed fire. Such information could also be provided at the Volcano Art Center, Volcano House, and the Kilauea Military Camp.

SOCIOECONOMICS

Tourism is the largest sector of the Hawai`i state economy. Hawai`i Volcanoes National Park is the single most visited tourist destination on the island of Hawai`i with 2.3 million recreational and nonrecreational visitors per year. State Route (SR) 11 encircles the island of Hawaii and passes through Hawai`i Volcanoes National Park. It is a primary route to the park, as well as a primary route between the town of Hilo, approximately 25 miles east of park headquarters, Kailua-Kona, approximately 90 miles west of the park, and numerous small towns.

A number of small communities are adjacent to or in close proximity to the park. The communities such as Volcano, approximately one mile east of park headquarters, and Pahala, Na`alehu, Waiohinu, and Ocean View, which are near the Kahuku Unit, provide services, such as gas, food, and lodging, to visitors enroute to or returning from the park. Hilo, a city of approximately 75,000 individuals, is the main commercial support center for the park.

Fire frequency is generally low in the park, with little to no effect to surrounding communities in relation to effect on tourism. However, several prolonged fire incidents have occurred in the park, which did result in economic opportunities for local communities. The park suppressed lava caused fires for two, 2-week periods in 1992. There were prolonged lava caused fires in 2002 and 2003, which lasted 14 months. In 1987 and 2000 there were three large, human-caused fires, each lasting for about three weeks. These large fires involved the participation of Mainland fire crews, which lodged at the Kilauea Military Camp, in Hilo, or in Volcano. Local caterers were hired for portions of the prolonged fire incident in 2002 and 2003. The prolonged fires required intensive use of helicopter support from state helicopter vendors. Finally, they also involved the hiring of small numbers of local residents for logistics and fire fighting duties. Up to 10 individuals from the community were hired on an emergency hire basis for the fires. Over $5 million dollars were expended on the fires in 2002 and 2003, with over half of this cost going towards local helicopter uses, caterers, and lodging.

PRIME OR UNIQUE FARMLANDS

There is generally little agriculture near the park. The park is largely bordered by state owned forest reserves or large private, partly forested holdings with dispersed cattle grazing. However, there are prime or unique farmlands near the park. There is an approximately 40 acre vineyard located immediately adjacent to the park at 4,000 foot elevation next to the Volcano Golf Course Subdivision (Mid-Elevation Seasonal FMU 5). Soils are infrequently tilled and grass fuels exist between the rows of vines. There is only one other vineyard in Hawaii. In 2000, a fire starting on the park boundary with the vineyard burned into the park and backed into the vineyard. There is a five acre

Macadamia nut orchard on Lorenzo Road, immediately south of the pastures in Kahuku (Kahuku Pasture FMU 7). The 3,500 MacFarms of Hawaii Macadamia nut orchard is located at least five miles from the nearest park boundary at Kahuku, north of Ocean View (Montane Seasonal Fire Management Unit 5). However, the area between MacFarms and the park boundary is dry, mesic forest and is vulnerable to fire. A fire spread from Yee Hop Ranch north of this forest into Kahuku in 1993. Macadamia nut orchards are typically kept free of understory vegetation because of herbicide use or tilling. Because of this, the potential for fire spread in macnut orchards is minimal.

CULTURAL ENVIRONMENT

Hawai`i Volcanoes National Park's cultural resources are varied and have been documented to include nearly 1,500 years of past human activity. The resources at Hawai`i Volcanoes National Park exemplify the full range of indigenous island cultural adaptations to a unique lava landscape. Also found throughout the park are the historic resources associated with post-contact exploration, settlement, ranching, tourism, scientific research, and national park development.

This EA will discuss four cultural resources classifications: archeological resources, historic structures, cultural landscapes, and ethnographic resources. Wildland fire and associated suppression activities may potentially affect historic properties (cultural resources) listed on or eligible for the National Register of Historic Places (National Register). These features, structures or sites are important for contributions to our collective heritage and are significant on a local, state, or national level.

The following list is a sample of the National Register listed and eligible properties within the park. It represents diverse site types and locations within Hawai`i Volcanoes National Park.

> Puna-Ka`u Historic District – 127,000 acres, mostly the coastal and leeward or dry portions of the park extending to the southeastern and southwestern boundaries of the park. Included in this district are over 107 designated sites identified by 4,596 features that include several petroglyph fields, village complexes, historic trails, and caves. One of the petroglyph fields within designated wilderness includes approximately 23,000 individual images or carvings in stone. (FMU 5)
>
> Pepeiau Trail Cabin – Only remaining trail cabin built as part of 1935 Master Plan for park. (FMU 5)
>
> `Ainapo Trail – Also known as the Menzies trail, approximately 7 miles of trail exist within the park from 12,560 feet to 13,240 feet. The trail continues out of the park from 12,560 feet to 11,600 feet in elevation where it disappears. Boundaries of the trail are 200 feet on either side of the trail. This prehistoric trail gained further significance as the route up Mauna Loa that was used historically by visiting explorers and scientists. (FMU 1)

Mauna Loa Truck Trail – Originally constructed in 1915 by the U.S. Army, with modifications to the road and route in 1935. This trail was constructed to provide access to the Mauna Loa summit for volcanologists and the public. (FMU 4)

Wilkes Campsite – The only remaining campsite within the Pacific attributed to the U.S. Exploration Expedition team that set out to map the Pacific in 1841. The site is at the 13,240 foot elevation at the edge of Mokuaweoweo. (FMU 1)

Red Hill Rest House and Pit Toilets – Built in 1915 by Company E, 25th Infantry Division, U.S. Army with funds provided for materials by the Hawaiian Volcano Research Association. The structure is located at the 10,000 foot elevation. (FMU 1)

Summit Rest House – Built between 1934 and 1936 with funds donated by the Hui O Pele organization and located at the 13,240 foot elevation. (FMU 1)

1790-Footprints - Approximately 711 archeological features and 3,500 individual fossil footprints within 8,000 acres. (FMU 5)

Footprints Shelter – A Civilian Conservation Corps constructed shelter built ca. 1941 as part of the park's master plan (September 1939 drawing, Museum Shelter for Footprints, Kilauea Section, Hawaii National Park). (FMU 5)

Mauna Loa Observatory Shelter – Octagonal stone structure built in 1937 as part of intensive efforts and planning to improve the park's visitor facilities. (FMU 4)

Table 3 presents the current number of the park's recorded archeological sites and features, and historic structures located within each FMU. These totals were generated primarily from the current park cultural resources GIS database and from parkwide GIS coverage. The totals reflect the results of survey efforts that began in 1890, prior to the formation of the park, through the current and ongoing survey efforts. Approximately 98% of the park still needs to be surveyed so this list should be considered incomplete.

Table 3. Cultural Resources Identified By Fire Environment/Fire Management Unit.

Fire Management Units	*Archeological Features/Sites*	*Historic Structures*
FMU-1 (Alpine)	16	20
FMU-2 (Subalpine)	44	2
FMU-3 (Mesic/Wet Forest)	3,252	67
FMU-4 (Montane Seasonal)	16	3
FMU-5 (Mid-Elevation Seasonal)	7,718	108

FMU-6 (Coastal Lowland)	4,414	9
FMU-7 (Kahuku Pasture)	15	-

The data presented in Table 3 indicates that wildland fire suppression and prescribed fire activities in Mid-Elevation Seasonal, Coastal Lowland, and Mesic/Wet Fire Management Units present the most difficult challenges to reducing associated impacts to cultural resources. Recent aerial reconnaissance of the high elevation slopes of Mauna Loa (Alpine and Subalpine Fire Management Units, FMUs 1 and 2) revealed limited cultural resources at these higher elevations. The reduced number of cultural resources combined with sparse vegetation and light fuel loads reduces or eliminates fire effects in FMU 1 and 2. Few archeological surveys have been conducted in both the Montane Seasonal (FMU 4) and in the Kahuku Pasture (FMU 7) areas. Future surveys conducted within these areas will likely reveal additional unique cultural resources.

The limited amount of cultural resource surveys conducted within the park combined with the remoteness of lava ignited fire activity contribute to the challenges of cultural resource protection. Fire management activities with the park require careful planning and consideration of cultural resources in all FMUs.

Archeological Resources

Archeological features and sites exemplifying the Native Hawaiian adaptations are found throughout the park, from sea level to over 13,400 feet. These resources include a range of features and sites representing resource procurement, such as salt and fish drying features and water collection features in caves; agriculture, such as stone mounds and excavated pits, both used for cultivation of sweet potatoes; residential and ceremonial sites, such as stone habitation platforms and terraces, walled enclosures, villages, and ceremonial construction (heiau); trails; and boundary markers.

Limited systematic survey limits knowledge of the complete distribution of archeological features and sites within the park. However, based upon the available information a few generalizations can be made. Identified cultural resources are clustered in the east/southeastern portion of the park in the coastal lowland fire environment (FMU 6) and in the immediate adjacent upland areas (FMU 5). The concentrations represent the remains of dense coastal habitation villages that were present at the time of European contact (ca 1778). The extensive agricultural features distributed within the upland areas represents the intensive agricultural pursuits practiced by Native Hawaiians intermixed with habitation areas that facilitated all phases of crop procurement. These resources are distributed in both grassy fuel types and in sword fern and uluhe, both of which generate low to moderate burn severity; the lack of larger woody debris reduces the effects of wildland fire on these resources.

A second concentration of cultural resources occurs in the Ka`u Desert and the area north of Kilauea Caldera, both located in the Mid-Elevation Seasonal Fire Management

Unit (FMU 5). These resources represent resource procurement that focused on utilizing fine grained basalt ejecta for traditional Hawaiian tool manufacturing including stone adzes that were used for a variety of common uses including: canoe making, house construction, ceremonial (heiau) construction, agricultural pursuits, and fine woodworking activities. Temporary habitation features including C-shape and cave shelters are intermixed with the quarry sites. Trail routes course through the area and give evidence of the transportation corridors that passed through the Kilauea portion of the park. The Footprints area provides evidence of human and animal interaction with the park's active geology through fossilized footprints. These footprints were created as humans and animals walked through the ash laid down during the 1790 Kilauea eruptions.

The dense site and feature clusters that were recorded in the coastal lowlands, Ka`u desert, and area north of the Kilauea Caldera represent a modified cultural landscape with activity areas intermixed with areas of less or no cultural activity. Identification of these sites and features resulted from survey efforts directed in these specific areas. Other sites and features will undoubtedly be located throughout the park as a result of future archeological surveys. It is expected that surveys will continue to find a similar pattern to what has already been observed, that the park's feature and site distribution will vary in density and quantity from dense site and feature concentration areas, to those of more isolated site and feature areas. While much of the park has yet to be surveyed, it is clear that archeological resources are distributed throughout the park, in each of the fire environments (FMUs).

Historic Structures

The historic structures presented in Table 3 are included on the park's List of Classified Structures (LCS). The LCS is a NPS database of historic structures that includes the full range of structures including buildings, monuments, trails, roads, fences, and structural ruins. Each LCS listed structure is considered eligible for or listed on the National Register. Historic structures are located throughout the park with the highest concentration found in two areas, in the park headquarters area (the Maintenance and Administrative Area Historic District) and the Kilauea Military Camp (KMC) Historic District. Both districts have been determined eligible for the National Register. Historic structures most vulnerable to wildland fire include approximately 100 structures located within the two previously mentioned historic districts (Mesic/Wet Forest Fire Management Unit, FMU 3) and the Pepeiau Cabin, Hilina Pali Shelter, and `Ainahou Ranch House facilities (Mid-Elevation Seasonal Fire Management Unit, FMU 5). These mostly wooden structures are especially vulnerable to the direct effects of fire. Other LCS resources include either mostly stone and mortar structures or structures that are located in areas not prone to wildland fire. These are factors that reduce the probability and severity of wildland fire effects. Historic structures are particularly vulnerable to the effects of fire and this needs to be a consideration in fire management. Fire suppression directed in areas with historic structures must first emphasize fire fighter safety and protection of human life.

Cultural Landscapes

A total of 19 areas in the park have been designated as cultural landscapes and are listed in the NPS Cultural Landscape Inventory (CLI) database (Table 4). These areas contain many of the park's historic structures. Cultural landscapes are subject to the effects of wildland fire and fire suppression activities. Impacts to these listed resources may have a greater magnitude because impacts are not isolated to single sites or features but are directed on a larger scale and have the potential of altering the entire landscape that encompass these resources.

Table 4. CLI Resources Within Hawai`i Volcanoes National Park.

CLI ID Number	*CLI Name*
975039	`Ainahou Ranch
975080	Chain of Craters Road
975082	Crater Rim Drive
975061	Hilina Pali Road and Shelter
975067	Halema`uma`u Overlook
975107	Hawaiian Volcano Observatory and Jaggar Museum
975051	Sulphur Bank
975063	Crater Rim Trail
975057	Kahuku Ranch
975055	Ka`u Desert Trail
975050	Kilauea Historic District
975041	Landing Fields
975079	Mauna Loa Strip Road
975072	Kipuka Puaulu (Bird Park)
975052	Wilkes Campsite and Ainapo Trail
975045	Kilauea Military Camp
975044	Kilauea Iki Overlook
975108	`Ainahou Ranch House and Designed Landscape
975081	Thurston Lava Tube

The Kahuku Unit has not been surveyed for cultural landscapes. However, ranching efforts have been an integral and contiguous component on the landscape for the previous 142 years and a cultural landscape survey is needed.

Ethnographic Resources

A series of reports prepared for the National Park Service (Langless 2003) present the findings of a four year study concerning historic and ethnographic resources located within the park. The reports contributed to the refinement of park resource management policies as they related to traditional Hawaiian use within the park. Langless utilized archival material and informant information in the preparation of the reports. Traditional activities conducted within the park (ca 1800-1900) included water

collection, canoe and canoe ladder construction, cultivation, bird hunting, and salt-making. Other nineteenth century activities focused on commercial trade industries including the sandal wood trade, goat ranching, crop cultivation, and pulu harvesting (the soft hairy fiber found on budding tree fern fronds) (Langless 2003: 33-48). Finally, the reports addressed recent and current resource use within the park. While focusing primarily on marine resource use, such as traditional fishing by both Kapapala and Ka`u area residents, the reports also documented hunting practices and plant collection activities that continue within the park. The plant collection activities are primarily associated with lei making for hula.

Ethnographic studies have not been conducted in the Kahuku Unit at this time.

Cultural Resource Significance

Terms found in section 106 of the National Historic Preservation Act (NHPA) and 36 CFR Part 800, the implementing regulations for the NHPA, are used to describe cultural resource significance (National Register eligibility) and effects on National Register listed or eligible resources. According to the regulations, cultural resources (also known as historic properties) that are determined eligible for or listed on the National Register must be considered during project planning and implementation. Cultural resources that are determined to be ineligible for National Register listing do not need to be considered. The process starts with resource identification. The next step is evaluating the cultural resource for National Register eligibility by determining if it has local, state, or national significance. If it is determined to have significance, then the resource is considered eligible for National Register listing. Some park cultural resources have been listed on the National Register but many have just been determined eligible for listing. For purposes of section 106 of the NHPA and 36 CFR Part 800 (cultural compliance process), National Register listing and National Register eligibility are given equal weight. National Register listing is not a requirement; however, it is a requirement to determine National Register eligibility. For activities such as wildland fire suppression, it is not usually feasible to survey an area and determine National Register eligibility before fire suppression activities begin. In these instances, cultural resources would be treated as if they were eligible to the National Register.

The park's cultural resources (historic properties) that have been determined eligible for or are listed on the National Register represent a range of significance from local to national. Each cultural resource is comprised of a set of attributes, called significant characteristics, which lend importance to that resource. Many of the park's cultural resources are individually on the lower end of the significance scale; however, collectively, they contribute to understanding the park's cultural history (prehistoric, historic, and traditional lifeways). Examples of this include small, rock scatters or non-formally shaped rock mounds. Such resources typically have low data potential and diminished integrity due to historic land-use practices, and would generally not qualify as eligible for National Register listing. However, when one considers that much of the prehistoric archeological record found at the park was heavily impacted by natural lava flows, small, rock scatters and mounds command greater importance as sources of information for understanding Hawaiian prehistory and settlement patterns. As such,

these features and sites deserve consideration when threatened by impacts from fire management actions. Unless deserving otherwise (e.g., modern trash scatters or sites determined ineligible though the evaluation process), all cultural resources will be considered eligible for National Register.

Fire Effects

Fires and associated factors can affect cultural resources. These effects result from wildland fire and fire suppression activities, as well as post fire rehabilitation efforts and are characterized as direct, operational, or indirect. Direct effects result from direct impacts created by the fire itself. Operational effects occur as a result of fire suppression operations. Indirect effects are a result of environmental alterations within the post-fire environment that may create adverse changes in the integrity of a resource. Environmental changes may also benefit the identification of cultural resources by increasing ground surface visibility that in turn increases survey effectiveness and the identification of previously unknown archeological resources. Similarly, fire suppression related activities may help identify resources in previously unsurveyed areas.

CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

METHODOLOGY

The analysis of impacts follows the same general approach for most impact categories. When possible, impacts were identified and evaluated using published literature and unpublished reports and data. For example, data on fire effects on vegetation in most zones of the park is readily available in the scientific literature and in park reports and databases. In some instances, data was not available but impacts were inferred from known effects of fire, e.g., effects on bird habitat by killing of above ground portions of `ohi`a trees. Cultural resource impacts were assessed through a presence/absence determination of cultural resources and by mitigation measures to be employed during wildfire suppression and prescribed fire activities. In addition, the Fire Management Archeologist for the National Park Service (Pacific West Region) was also contacted to describe in further detail potential impacts of fire and fire-related activities on cultural resources in the park. In cases where data was not available, the observations and best professional judgment of experienced individuals were relied upon, e.g., the observations of fire impacts on archeological resources by staff archeologists made during wildland fires.

For the purposes of this EA, direct and indirect environmental impacts and cumulative effects of project alternatives are analyzed in terms of geographical context (site-specific, local, state, or national), duration (short or long term), and intensity (negligible, minor, or major). Direct impacts are caused by an action that occurs at the same time and place.

Impact Definitions

***Negligible impact*.** No resources are present or there are resources present, but the action would have no direct and/or indirect impacts or only temporary impacts are expected.

Minor impact. The action would have permanent direct and/or indirect impacts on resources; however, the impacts are not substantial and highly noticeable or conditions can be imposed that mitigate and/or avoid the impacts being substantial and highly noticeable.

Major impact. The action would have permanent direct and/or indirect impacts on resources that are substantial and highly noticeable.

Direct impact. Direct impacts are those that are caused at the same time and place as the action. In this case, these are the impacts of fire or suppression operations.

***Indirect impact*.** Indirect impacts occur later in time and at a distance.

Cumulative Impact. Cumulative impacts are the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions.

If there are indirect impacts or cumulative impacts in the following analysis, they will be specifically referenced by these terms. If these terms are not used in the analysis, then indirect and cumulative impacts are not expected.

Impairment

An impairment finding is required for each resource as part of the environmental analysis of project alternatives (*Director's Order #12: Conservation Planning, Environmental Impact Analysis, and Decision-Making*). The NPS Management Policies (2001) state that impairment is an impact that would harm the integrity of park resources or values. Whether an impact meets this definition depends on the particular resources and values that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impacts; and the cumulative effects of the impact in question and other impacts. An impact to any park resource or value may constitute an impairment. An impact would be more likely to constitute an impairment to the extent that it affects a resource or value whose conservation is:

- Necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
- Key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park; or
- Identified as a goal in the park's general management plan or other relevant NPS planning documents.

An impact would be less likely to constitute an impairment to the extent that it is an unavoidable result, which cannot reasonably be further mitigated, of an action necessary to preserve or restore the integrity of park resources or values. Hypothetically, impairment may occur from visitor activities, NPS activities in the course of managing a park, or from other government agencies, concessioners, contractors, cooperators, or others operating in the park.

NATURAL ENVIRONMENT, VISITOR USE AND EXPERIENCE, SOCIOECONOMICS, AND PRIME OR UNIQUE FARMLANDS

Alternative 1 (No Action) Impact Analysis

Continue current fire management policies, goals, and strategies described in the approved, 1990 Fire Management Plan. These include immediate suppression of all unplanned fires of human origin and suppression of all wildland fires, with no role for wildland fire use (that is, all lightning and lava caused fires will be suppressed). The no action alternative provides for experimental use of prescribed fire for ecological

restoration and for rare species recovery. Prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries. This alternative also allows the limited use of manual and chemical treatments to prevent the widespread establishment of new alien grasses and facilitate revegetation of native plants.

Under this alternative, the park would continue to control invasive fountain grass, a potentially hazardous fuel that colonizes young, sparsely vegetated lava flows and dry forests and shrublands. The park would maintain or establish fuel breaks in fire-prone areas or at high value resource areas, either mechanically or by establishing fire-resistant vegetation. The park would revegetate burned areas with fire-tolerant native vegetation if feasible and necessary.

Air Quality

Continuing the current policy of suppressing all wildland fires in Hawai`i Volcanoes National Park would have a beneficial effect on air quality by minimizing the amount of particulate matter entering the atmosphere. Most wildland fires would have minor, short-term impacts on air quality because of the small size and short duration of most park fires. Moreover, prevailing trade winds would quickly carry smoke out of the park to the ocean, although smoke from park fires may possibly add to volcanic and anthropogenic (human-caused) pollution on the leeward side of the island. Should a wildland fire escape initial attack and grow to a large size such as 50 acres or more, longer lasting negative effects to the park's air quality would occur. The impacts would be in terms of reduced visibility for park visitors and could last for one or more days.

Small research burns are permitted under *Alternative 1,* potentially increasing the amount of smoke produced. To date, this has had a very small impact because only eight burns have been conducted; the largest of which was 103 acres with a burning period of approximately four hours.

Alternative 1 would have local, direct and indirect, short term, negligible to minor, beneficial effects on air quality by minimizing fire occurrence. The effects are negligible to minor because smoke inputs from fire would be short term and localized. Prescribed fire would have direct, but short term and localized, negligible to minor adverse effects on air quality. Cumulative actions are natural localized, high ambient levels of volcanic gases (anthropogenic sources are negligible). Smoke from fire would be added to air quality strongly affected by volcanic gases. The fire exclusion policy of *Alternative 1* would result in negligible or minor cumulative effects. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Soils

A policy of suppressing all wildland fires would reduce the potential for erosion. Fire knocks back vegetation, thus exposing soil to rain or overland flow during heavy rains immediately after fire. Impacts of this alternative on soils will be negligible to minor.

The potential of post fire soil erosion is low because of rapid revegetation in grassy fuels and the persistence of litter and humus layers in rain forest and mesic forest fuels. Most park fires are in fire-promoting alien grasses. These grasses quickly recover by vegetative resprouting within weeks to protect soil. They reach approximately pre-burn cover in 18-24 months (Tunison *et al*. 1995). Often the biomass of alien grasses is greater after fire than before fire. Other common fuels are sword fern and uluhe. A protective thick litter mat persists after all but the most intense fire in these fuels.

Although erosion has not been systematically documented or quantified as a fire effect, it is only rarely observed after fire. An exception was the Kealakomo prescribed fire in 1999. Erosion was seen after extremely heavy rains (30 inches in 24 hours in nearby locations) in the experimental Kealakomo prescribed fire area.

Use of manual and chemical treatments to prevent widespread establishment of invasive grasses would be extremely localized. Treated areas would be generally no larger than the size of an individual (<2 ft diameter). In the case of revegetation, treated areas would be small, $\leq$ 20 $m^{2,}$ and would be quickly followed-up with outplanting and seeding with native vegetation. Chemical treatments would be used for 1) initial knockdown, and 2) temporary removal of grasses. No long-term recurrent use of chemicals would be used within a site. In addition, Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses is applied, and impacts to the surrounding area would be minimized. Consequently the potential of contamination and erosion is low. Impacts of this alternative on soils will be negligible to minor.

Alternative 1 could have site-specific, short-term, indirect, negligible to minor adverse impacts on soils. Actions that would have cumulative effects are resource management programs to control feral ungulates and restoration of native vegetation. These activities would result in beneficial cumulative effects of increased vegetation cover and reduced erosion. Soil erosion from park development and visitation is negligible. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Water Resources and Wetlands

The potential for fire spread near water resources is extremely low, and there is no history of fire in the park near wetlands except near some anchialine pools near the shoreline. Fuels are sparse and intermittent or wetlands are located in very wet, tree fern rain forest. In any case, the fire exclusion approach of Alternative 1 would help protect wetlands and water resources in the park from alteration of wetland vegetation

and sedimentation. Because the potential for erosion is low after fire, the risk of contamination and sedimentation in wetlands is low. Retardants are not used in fire suppression and therefore pose no threat to wetlands. Foam may be used in fire suppression. Resource Advisors will monitor the use of foam during fire operations to avoid its use near or in wetlands. Herbicides may be used in the control of hazardous fuels such as fountain grass. Use of herbicides near wetlands will be avoided.

There is a potential for cumulative impacts if invasive plant species control occurs near wetlands. However, use of manual and chemical treatments to prevent widespread establishment of invasive grasses would be extremely localized and would not occur in the vicinity of water resources. In addition, Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses would be applied and this would minimize impacts to the surrounding area. The potential for contamination and sedimentation would be low.

Impacts of *Alternative 1* on Water Resources and Wetlands would be site specific and local, short and long term, indirect, negligible to minor adverse impacts. Cumulative effects from park invasive species control and restoration programs would be minor or negligible because of mitigation. Other cumulative effects on wetland may result from ungulate control, which encourages the regeneration of native vegetation. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Wilderness

A policy of suppressing all wildland fires, under *Alternative 1*, applies to the entire park, including wilderness. On the one hand, suppression of fire in wilderness protects native plant ecosystems from invasive species and thus helps achieve stated park wilderness values of ecological integrity and biological diversity. Revegetation of burned areas also enhances these wilderness qualities.

On the other hand, suppression of fires in wilderness has impacts on wilderness quality. Low level helicopter flights, fire lines, water drops, staging areas, campsites, mop up operations, and revegetation efforts increase signs of human presence in wilderness. All of these actions have been deemed in past fires to be the minimum tool for fire operations in wilderness.

Human impacts are reduced in fire planning by following the Minimum Requirement decision making process outlined in Appendix 2. Human impacts would be reduced during suppression operations by following Minimum Impact Suppression Tactics.

Alternative 1 would have local, short and long-term, direct and indirect, minor adverse impacts on Wilderness because of fire suppression operations in wilderness. Impacts from fire operations on wilderness would be cumulative with the effects of other administrative actions in wilderness to control invasive species and restore native ecosystems. These include such actions as installation of fences, control of feral

animals, and removal of invasive plant species. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Soundscape

Fire suppression activities under *Alternative 1* would have short-term impacts on the natural soundscapes of the park, primarily because of the extensive use of helicopters in fire suppression. Natural soundscapes would also be affected by weedeaters and chain saws, which are used for fire line construction.

Alternative 1 would have site specific and local, short-term, direct and indirect, negligible, adverse impacts on the soundscape. There are cumulative impacts with this alternative because of impacts of other sound sources such as the administrative use of power tools, vehicles, and helicopters for other park purposes, as well as impacts by visitors in vehicles, on air tours, on trails, or in developed areas. These are not expected to change because administrative functions and visitation are stable and no new developments or alternative transportation systems are planned. The volume of air tours may change as a result of the Air Tour Management process, which is currently underway in the park. However, predictions can't be made at this time as to what the change might be. *Alternative 1* would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Wildland/Urban Interface

Alternative 1 provides for maximum protection of life, property, and resources in the wildland/urban interface because it requires all fires to be suppressed, does not allow fire use, and includes only a minimal role for prescribed fire in the park. Existing fuel breaks would be maintained.

Alternative 1 would have local, long term, direct and indirect, negligible beneficial impacts on the Wildland/Urban Interface because of a fire exclusion policy and mitigation requirement that precludes research (prescribed) burns in the Wildland/Urban Interface. As a cumulative effect, increased development outside the park in the Wildand/Urban Interface probably increases the chance of fire starts, which increases fire potential along the park boundary. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Vegetation, Wildlife, and Native Ecosystems

Vegetation. Fire impacts on vegetation vary by ecosystem. Responses of park plant communities to fire by ecological zone or Fire Management Unit have been characterized in the Affected Environment section.

In general, under *Alternative* 1, effects of fire on vegetation would be minimized or avoided by requiring suppression of all fires and restricting the application of prescribed fire. Native vegetation would be protected from the impacts of fire and disturbance that facilitates the spread of invasive alien vegetation. Native plant species in many communities are reduced in abundance after fire and invasive species abundance is enhanced.

Salt water helicopter bucket drops made during suppression operations appear to have had no impacts on vegetation. Expected signs of impact would be uprooting, bleaching, loss of vigor, and mortality. These signs have not be observed. Bucket drops are used in coastal areas, which are exposed to high ambient levels of salt spray and presumably plants are adapted to this high salt level.

Specific benefits of fire exclusion are summarized for different fire environments. ***Alpine and Subalpine***--The exclusion of fire would protect the scattered `ohi`a trees and pukiawe shrubs, which are fire-sensitive, as well as small patches of native, fire-sensitive pukiawe shrubs. ***Montane Seasonal***--Fire exclusion would allow the maturation of koa forest communities and the potential development of native understory vegetation in these communities. The spread of fire in the species-rich, mixed forest stands of Kipuka Ki and Kipuka Puaulu would probably be highly destructive to overstory plants such as koa, `ohi`a, and manele and the numerous understory tree and shrub species whose response to fire is unknown. ***Mesic/Wet Forest***--Keeping fire out of mesic and wet forest plant communities would prevent the loss of overstory `ohi`a and understory trees, tree ferns, and uluhe fern, which inhibit the spread of weedy species such as cane tibouchina and broomsedge. ***Mid-Elevation Seasonal***--Exclusion of fire would greatly affect areas where fire sensitive `ohi`a and pukiawe remain. The plant communities in these zones would benefit by preventing the loss of the fire-sensitive community dominants, `ohi`a and pukiawe, and the spread of invasive molasses grass, broomsedge, and beardgrass. ***Coastal Lowland***--Exclusion of fire would protect relictual elements of the `akia shrubland in the eastern portion of the coastal lowlands. Fire exclusion may have a minor impact on pili grass, which is a fire stimulated species. ***Kahuku Pasture***--Fire exclusion would protect the remnant `ohi`a overstory.

No plant species or plant community appears to be dependent on fire, at least in the time frames of fire effects and plant community monitoring conducted by park staff or researchers. The exclusion of fire would therefore not adversely affect the regeneration of native plants or perpetuation of native plant communities. However, pili grass, while not fire-dependent, is a fire-stimulated species and has a history of responding to fire in the lowlands.

Fire suppression will minimize fuel loadings of alien grass fuels in ecosystems with alien grasses or ferns, where fires have been most prevalent in the park. Fuel loadings of invasive grasses are increased by fire as much as two to three fold.

Control of hazardous fuels such as fountain grass has a positive effect on park native plant communities. Fountain grass is a fire-promoting grass that invades dry, young

lava flows creating hazardous fuel conditions. It also invades the understory of dry woodlands and forest. Non-target effects of chemical treatments on native vegetation would be minor to negligible. Treated areas would be confined to areas dominated by alien grasses. Chemical treatments would be used for initial knockdown of alien grasses. Long term recurrent use of herbicides within a site would be avoided. Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses is applied, and that impacts to the surrounding area would be minimized.

Impacts of experimental prescribed fire on vegetation are expected to be positive for plant communities that are highly degraded by alien grasses and wildfire. These are largely alien or pili-alien grasslands where the impacts of fire on resources are minor. Prescribed fire, in combination with revegetation, has proven to be an effective method for establishing fire-tolerant native vegetation.

Alternative 1 would have site specific and local, long-term, direct and indirect, minor or potentially major, beneficial impacts on the vegetation because of its fire exclusion and prescribed fire approach. Cumulative beneficial impacts could be expected on vegetation from other resource management programs. These include feral ungulate control, alien plant control, and restoration with outplantings and direct seeding of native plants. Fire exclusion contributes to the control of invasive species and maintenance of native vegetation. Restoration after fire, a component of both *Alternative 1* and *Alternative 2*, contributes to native ecosystem restoration. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Wildlife. The direct impacts of fire on wildlife have not been studied in Hawai`i. It is inferred that exclusion of fire under *Alternative 1* would help perpetuate birds and invertebrates dependent on native vegetation. Because fire readily top-kills native `ohi`a and koa, the two most important host overstory trees in Hawaiian forests and woodlands, along with other native trees and shrubs, birds and invertebrates populations are undoubtedly reduced by fire. To the extent that vegetation after fire is dominated by invasive species in some ecosystems, a shift from native wildlife to species able to utilize alien plants could be expected.

In the long-term, limited control of alien grasses to prevent widespread establishment of new species, or to facilitate native revegetation improves habitat quality for native wildlife. Whenever possible, chemical and mechanical treatments would be conducted away from native bird habitat. Chemical treatments would be used for an initial knockdown of alien grasses in small localized sites. Long-term recurrent use of chemicals within a site would be avoided. The potential risk to wildlife would be mitigated by close consultation with Resource Advisors to avoid areas where native wildlife is suspected of inhabiting. Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses would be applied, and that impacts to the surrounding area would be minimized.

Alternative 1 would have site specific and local, long-term, direct and indirect, minor to major, beneficial, impacts on wildlife by excluding fire and maintaining wildlife habitat. Other restoration efforts including feral ungulate control, alien plant control, invasive species control, and native plant community restoration would have cumulative, beneficial impacts by restoring native ecosystem habitat. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Threatened and Endangered Species and Species of Special Concern. A policy of suppressing all fires best protects threatened and endangered species and species of special concern. An appropriate management response for suppression incidents will be guided by the presence of rare species that may be affected by fire. Maps of the distribution of threatened, endangered, and species of special concern will used to develop fire suppression tactics to keep fire out of areas with these species.

The response of threatened, endangered, and most species of special concern to fire has not been documented by fire effects studies. However, the response may be generally inferred from the response of related species. On the whole, fire is probably harmful to most rare plant species. Some rare plant species may resprout or become established from seed. However, a number of native Hawaiian plant species do not respond favorably to fire in this way (Smith and Tunison 1992, Mueller-Dombois 1982). Fire may alter the habitat of rare plant species and affect their reestablishment through changes in their biological and physical environment, e.g., loss of important canopy species or introduction of invasive competitive species. Rare plant species are inherently vulnerable to loss by fire because of small population size.

Fire may also be largely harmful to rare forest bird species. Fire may remove food and nesting resources by altering vegetation, particularly by removing canopy trees or understory plants forest birds depend on.

In the long term, control of alien grasses to prevent widespread establishment of new species, or to facilitate native revegetation efforts improves habitat for endangered and rare species. Whenever possible, chemical and mechanical treatments would be conducted away from native bird habitat and from rare plants. The potential risk to rare species would be mitigated by close consultation with Resource Advisors to avoid areas where they are present. Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses would be applied, and to minimize impacts to the surrounding area. Consequently, the effects of these treatments would be expected to be minor to negligible.

Alternative 1 would have site specific or local, long-term, direct and indirect, minor or potentially major, beneficial impacts effects on the threatened and endangered species and species of special concern. Fire exclusion would protect these species and their habitats by preventing the spread of invasive species after fire. Invasive species control and ecosystem restoration work in the park will have beneficial cumulative effects by maintaining or enhancing habitat for rare species. This alternative would not impair

park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Caves

Fire may have an indirect, long-term effect on cave invertebrate communities by killing overlying `ohi`a trees, including their roots, the main carbon source for cave food webs. The largely fire exclusion policy of *Alternative 1* then benefits cave resources. Removal of overlying vegetation by fire may alter temperatures, air currents, and relative humidity; this possibility is under investigation. Cave adapted organisms tend to be located in caves with high, constant relative humidity. The fire exclusion policy of *Alternative 1* protects overlying vegetation, thereby protecting carbon sources and environmental conditions favorable for cave-adapted invertebrates.

Suppression operations may expose caves to exploration and damage by fire fighters or others attracted to the site by an initial exploration. Visitation in caves also damages `ohi`a root systems and the habitat for cave invertebrates. The potential impact of humans could be mitigated by excluding access or rerouting fire lines away from cave openings.

Alternative 1 would have site specific, short and long-term, direct and indirect, minor or possibly major beneficial impacts on the caves by excluding fire and protecting `ohi`a roots in the caves. There would also be cumulative, beneficial impacts from park invasive species and ecosystem restoration programs. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Visitor Use and Experience

Visitors could be inconvenienced by suppression activities. They may be restricted from areas of the park where fire activity is taking place because of concerns for their safety. In the past, the longest period of time visitors were restricted from major road areas of the park because of fire or fire operations was one week, even though there were fires occurring in the area for over one year.

Visitors in automobiles would be restricted from the lower portion of Hilina Pali Road and from the Mauna Loa Road when the fire danger is very high or extreme. In dry years, closures may be in effect for several weeks to several months of the year. `Ainahou Ranch house area is also closed during prolonged very high or extreme fire periods, restricting access for the general public and scheduled work and educational groups.

Viewsheds in the park may be affected by smoke from experimental prescribed fires; this could affect air tour visitors as well as other park visitors. Smoke effects on visibility would be reduced by the full suppression policy of this alternative. Fire may also affect the visual quality of the park in that fire produces burned landscapes, which may involve

loss of tree canopy and understory vegetation and the presence of charred vegetation. *Alternative 1* would result in the least extent of visually altered burned areas.

Alternative 1 would have site specific and local, short-term, direct and indirect, negligible minor adverse impacts on visitor use and experience. The impact of fire operations would be cumulative with other administrative actions in the park such as the maintenance of facilities and resource management activities. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Socioeconomics

Alternative 1 requires the suppression of all wildland fire. This may result in extended suppression efforts similar to those of 1987, 1992, 2000, and 2002-2003. Prolonged suppression efforts result in dramatically increased local purchases of helicopter, caterer, and lodging services, and an increase in purchases for supplies and materials. The minimal prescribed fire allowed under this alternative will involve small fires with modest staffing levels and helicopter support. The economic impact on the community from prescribed fire will be negligible.

Alternative 1 would have local, minor, short term, direct and indirect, beneficial impacts on the economies of local communities during prolonged suppression efforts. The cumulative impact of this alternative on the local tourist-based economy is expected to be negligible to minor with short term beneficial impacts.

Prime or Unique Farmlands

The total fire suppression policy of *Alternative 1* minimizes the potential for fires that start in the park to spread into adjacent or nearby prime or unique farmlands. The potential for soil erosion after fire and the potential for soil deposition on prime or unique farmlands is minimal. This is because of the rapid recovery of vegetation and the total fire suppression policy. Small, experimental prescribed fires will be allowed under this alternative. However, prescribed fire will only occur in those areas of the park where there are extensive barriers to fire spread past the park boundaries. The presence of these barriers would be critical factors in planning experimental prescribed fire in areas near prime or unique farmlands. This alternative also allows the limited use of manual and chemical treatments to prevent the widespread establishment of new alien grasses. Control of these plants in the park may benefit weed management in prime or unique farmlands.

Impacts of *Alternative 1* on prime or unique farmlands would be local, direct and indirect, minor, and largely beneficial because of fire suppression and alien grasses control. Cumulative effects from park invasive species control and restoration programs would be minor or negligible but these efforts might benefit unique farmlands through control of invasive species.

Alternative 2 (Proposed Action) Impact Analysis

This alternative includes all changes to be made to the park's Fire Management Plan: All unplanned fires of human origin would be suppressed. All fires of natural origin would be suppressed except for fires in isolated kipuka in the Coastal Lowland, Alpine, and Subalpine Fire Management Units that are surrounded by extensive lava flows and where resource damage such as loss of rare species or expected invasion of alien species would not occur. Prescribed fire would be used to help restore native vegetation in the coastal lowlands and mid-elevation seasonal woodlands. Fire use and prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries. The Coastal Lowland, Alpine, and Subalpine Fire Management Units are in areas where there are extensive lava flows along the park boundaries. The area where prescribed fire will be used in the Mid-Elevation Seasonal Fire Management Unit is near the Hilina Pali Road, 3-10 miles from park boundaries and bordered by lava flows and dense rain forest. The Mid-Elevation Seasonal Fire Management Unit does extend up to the Volcano Golf Course Subdivision; however, fire use (natural fire) is not proposed for this Fire Management Unit and prescribed fire will not be allowed in this portion of the unit.

Under this alternative, and in *Alternative 1*, the park staff would continue to control invasive fountain grass, a potentially hazardous fuel that colonizes young, sparsely vegetated lava flows and dry forests and shrublands. The park staff would maintain or establish fuel breaks in fire-prone areas or at high value resource areas, either mechanically or by establishing fire-resistant vegetation. The park staff would revegetate burned areas with fire-tolerant native vegetation environments if feasible and necessary. Limited use of manual and chemical treatments would continue to prevent the widespread establishment of new alien species and facilitate native plant revegetation, including rare plants.

Air Quality

Continuing the current policy of suppressing all unplanned human caused fires and most lava and lightning caused fires in Hawai`i Volcanoes National Park would have a positive effect on air quality by minimizing the amount of particulate matter entering the atmosphere. However, greater smoke production may occur under *Alternative 2,* than in *Alternative 1*. Prescribed fire may be used to suppress invasive grasses prior to outplanting and direct seeding in the Coastal Lowland and Mid-Elevation Seasonal Fire Management Units. However, the fires would occur under favorable smoke dispersion conditions (taking into account factors such as wind) and would adhere to any conditions imposed by Hawai`i state smoke permits. Some lightning and lava caused fires in the Coastal Lowland, Subalpine, and Alpine Fire Management Units may be allowed to burn. However, total smoke production would be expected to be minor, because fire for resource benefits will only be allowed in small, isolated kipuka.

Alternative 2 would have local, direct and indirect, short term, negligible to minor impacts on air quality. This alternative has largely a fire exclusion approach and fire

occurrence would be minimized. The effects are negligible to minor because smoke inputs from fire would be short term and localized. Allowing prescribed fire and fire use would have direct, short term, localized adverse effects on air quality. Cumulative actions are natural localized, high ambient levels of volcanic gases; anthropogenic sources would be minor. Smoke from fire would be added to air quality that is strongly affected by volcanic gases. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Soils

Alternative 2 would minimize the potential for soil erosion. It requires suppression of unplanned human-caused fire and most natural ignitions. There would be potential for an increase in the aerial extent of fire, and potentially erosion, under this alternative because prescribed fire is allowed as a restoration tool in the Coastal Lowland and Mid-Elevation Fire Management Units. Also fires of natural origin may be allowed to spread in some areas in the Alpine, Subalpine, and Coastal Lowland Fire Management Units. Impacts of this alternative on soils will be negligible to minor. The potential of erosion would be low because of rapid revegetation in grassy fuels.

Similar to *Alternative 1*, the limited use of manual and chemical treatments to prevent widespread establishment of invasive grasses would be allowed. Treated areas would be generally no larger than the size of an individual (<2 ft diameter). In the case of revegetation, treated areas would be $\leq$ 20 m^2 and would be quickly followed-up with outplanting and seeding with native vegetation. Chemical treatments would be used for 1) initial knockdown, and 2) temporary removal of grasses. No long-term recurrent use of chemicals would be used within a site. In addition, Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses would be applied, and to minimize impacts to the surrounding area. Consequently, the potential of contamination and erosion would be.

Alternative 2 would have site specific and local, short and long term, indirect, minor adverse impacts on soils. Actions that would have cumulative effects are resource management programs to control feral ungulates and restoration of native vegetation. These activities would result in beneficial cumulative effects of increased vegetation cover and reduced erosion. Soil erosion from park development and visitation would be negligible. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Water Resources and Wetlands

The potential for fire spread near water resources is extremely low, and there is no history of fire in the park near wetlands except near some anchialine pools by the shoreline. Fuels are sparse and intermittent or wetlands are located in very wet, tree fern rain forest. In any case, the largely fire exclusion approach of *Alternative 2* would

help protect wetlands and water resources in the park from alteration of wetland vegetation and sedimentation. Because the potential for erosion is low after fire, the risk of contamination and sedimentation in wetlands is low. Retardants are not used in fire suppression and therefore pose no threat to wetlands. Foam may be used in fire suppression. Resource Advisors will monitor the use of foam during fire operations to avoid its use near or in wetlands. Herbicides may be used in the control of hazardous fuels such as fountain grass. Use of herbicides near wetlands will be avoided.

Fire use in the Alpine and Subalpine Fire Management Units will not affect water resources and wetlands because these are not present in these areas. Fire use in the coastal lowlands has the potential to affect anchialine pools located at the shoreline. However, according to mitigation specified for *Alternative I*, fire use will not be allowed in areas where it can harm valuable resources. Prescribed fire in the Mid-elevation Seasonal Fire Management Unit will not affect water resources and wetlands because they do not occur there. The application of prescribed fire in the coastal lowlands will be avoided in areas with anchialine pools.

Similar to *Alternative 1*, limited use of manual and chemical treatments to prevent widespread establishment of invasive grasses would be extremely localized and would be prohibited in the vicinity of water resources. In addition, Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses would be applied, and to minimize impacts to the surrounding area. Consequently the potential for contamination and sedimentation would be low.

Alternative 2 would have site specific and local, short and long term, indirect, negligible impacts site on water resources and wetlands. Cumulative effects from park invasive species control and restoration programs would be minor or negligible because of mitigation. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Wilderness

Suppression of all human and most lava and lightning caused fires under *Alternative* 2 would help protect wilderness from invasive species. Impacts from fire suppression operations on wilderness can be expected including low-level helicopter flights, power tool use, water drops, and fire line, staging area, and landing zone construction. These would be mitigated by following Minimum Impact Suppression Tactics and Minimum Requirement/Minimum Tool decision-making process. All of these actions have been deemed in past fires to be the minimum tool for fire operations in wilderness.

Allowing natural fires to spread unhindered in certain areas of the alpine, subalpine, and coastal lowland wilderness under this alternative would have negligible or minor impacts on wilderness ecological integrity or biological diversity. Fire use would be allowed only where it does not threaten biological or cultural resources. Suppression impacts would

be avoided in areas where lava and lightning caused fires are allowed to spread to lava flow boundaries. Wilderness qualities of ecological integrity and biological diversity would be enhanced by the use of prescribed fire because this would enhance the restoration of native species.

Alternative 2 would have local, short and long term, direct and indirect, minor adverse impacts on wilderness because of fire suppression and prescribed fire operations in wilderness. The cumulative impacts would result from the effects of other administrative actions in wilderness to control invasive species and restore native ecosystems, in combination with fire operations. These other administrative actions would include installation of fences, control of feral animals, and removal of invasive plant species. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Soundscape

Under *Alternative 2*, there would be greater potential for short-term impacts on the natural soundscape. This alternative also would involve the possibility of fire use in the Alpine, Subalpine, and Coastal Lowland Fire Management Units and prescribed fire in the Coastal Lowland and Mid Elevation Seasonal Fire Management Units. Helicopters may be used to monitor the spread of wildland or prescribed fires and they may be used to support fire control and vegetation rehabilitation activities.

Alternative 2 would have site specific and local, short term, direct and indirect, negligible, adverse impacts on soundscape. There would be cumulative impacts with this alternative because of impacts of other sound sources such as the administrative use of power tools, vehicles, and helicopters for other park purposes, as well as impacts by visitors in vehicles, on air tours, on trails, or in developed areas. These would not be expected to change because administrative functions and visitation are stable and no new developments or alternative transportation systems are planned. The volume of air tours may change when the park's air tour management planning process is completed; it is currently underway. However, predictions can't be made at this time as to what those changes may be. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Wildland/Urban Interface

Alternative 2 requires suppression of almost all park fires. Wildland fire use would be allowed only in isolated kipuka of the Alpine, Subalpine, and Coastal Lowland Fire Management Units. These FMUs have extensive lava flows along the park boundaries, which serve as a barrier to fire spread. Prescribed fire would be used in the Coastal Lowland Fire Management Unit. Prescribed fire would also be used in the Mid-Elevation Seasonal Fire Management Unit near the Hilina Pali Road. This area is 3-10 miles from the park boundaries and is located by lava flows and dense rain forest. The Mid-Elevation Seasonal Fire Management Unit does extend up to the Volcano Golf

Course Subdivision; however, prescribed fire would not occur in this portion of the Fire Management Unit.

Alternative 2 would have local, long term, direct and indirect, negligible, beneficial impacts on the Wildland/Urban Interface because of mitigation. As a cumulative effect, increasing development outside the park in the Wildand/Urban Interface probably increases the chance of fire starts, which increases fire potential along the park boundary. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Vegetation, Wildlife, and Native Ecosystems

Vegetation. In general, under *Alternative 2*, direct, adverse impacts of fire on vegetation would be minimized by requiring suppression of most fires. Native vegetation would be protected from the impacts of fire, which facilitates the spread of invasive alien vegetation and the loss of native vegetation. The potential for increased fuel loadings of invasive, fire-promoting grasses in the Mid-Elevation Seasonal Fire Management Unit is lessened by natural fire exclusion. The benefits of fire exclusion on preventing the spread of invasive species and protecting native species are outlined by fire environment in *Alternative 1.* Wildland fire use would be allowed only in isolated kipuka of the Alpine, Subalpine, and Coastal Lowland Fire Management Units.

Fire use in the coastal lowlands would help maintain and enhance pili grasslands. Fire use would be restricted to isolated kipuka to prevent fire spread into the Mid-Elevation Seasonal Fire Management Unit mauka of the coastal lowlands. It would be restricted to kipuka in which favorable fire effects can be predicted and not allowed in kipuka with native trees. A number of native plant species in the subalpine and alpine will recover quickly after fire use in these environments, examples include native hairgrass and `ohelo, two major components of these environments. Pukiawe will be reduced in abundance but a`a`li`i will increase. The potential effect of allowing natural fires on other plant species, particularly on invasive species, in the alpine and subalpine is unknown. A mitigation for fire use in the Subalpine and Alpine Fire Management Units is monitoring to assess the role of fire and invasive plants in these environments.

Fire may negatively impact the scattered `ohi`a in the subalpine. Areas with concentrations of `ohi`a will be avoided in the application of fire use to this environment. The impact of fire on the scattered invasive grasses in the subalpine is unknown, particularly velvet grass and sweet vernal grass. These grasses tend to become more abundant after disturbance such as pig digging. The effects of fire use would be closely monitored. If fire stimulates invasive species to the detriment of native vegetation, then adjustments could be made in fire use policy in the Subalpine and Alpine Fire Management Units.

Alternative 2 would expand the role of prescribed fire as a restoration tool from small experimental sites to larger managed areas in Coastal Lowland and Mid- Elevation

Seasonal Fire Management Units. Areas targeted for management are dominated by alien grasses with very few remaining fire-sensitive native woody species. Prescribed fire would be used as a management tool to temporarily suppress invasive grasses to help establish outplantings and sown seeds of fire-tolerant native plants in native plant community restoration projects. The biomass or fuel loadings of invasive, fire-promoting grasses would undoubtedly increase in the Mid-Elevation Seasonal Fire Management Unit. However, with the help of prescribed fire, a diverse, plant community of fire-tolerant native species would be established. Prescribed fire in the coastal lowlands would result in an increase in native pili grass and a reduction in invasive grasses. Direct seeding experiments are currently underway to test the effectiveness of prescribed fire in helping establish fire-tolerant native shrub species, as well as stimulating pili grass.

As in *Alternative 1*, salt water helicopter bucket drops would continue to be used in the coastal lowlands. Plants in this area are exposed to high ambient levels of salt spray and salt water helicopter bucket drops made during suppression operations appear to have had no impacts on vegetation. The plants are presumed to have adapted to higher salt levels as they don't exhibit the expected signs of salt impact, which would be uprooting, bleaching, loss of vigor, and mortality

Similar to *Alternative 1*, control of hazardous fuels such as fountain grass has a positive effect on park native plant communities. Fountain grass is a fire-promoting grass that invades dry, young lava flows creating hazardous fuel conditions. It also invades the understory of dry woodlands and forest. Non-target effects of chemical treatments on native vegetation would be minor to negligible. Treated areas would be confined to areas dominated by alien grasses. Chemical treatments would be used for initial knockdown of alien grasses. Long-term recurrent use of herbicides within a site would be avoided. Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses would be applied, and to minimize impacts to the surrounding area.

Alternative 2 would have site specific and local, long-term, direct and indirect, minor to major, beneficial impacts on the vegetation because of its fire exclusion approach. Fire use would have localized beneficial effects on vegetation in the coastal lowlands, subalpine, and alpine zones through stimulation of fire adapted native species. Prescribed fire would have localized, beneficial effects on park vegetation. Cumulative beneficial impacts could be expected on vegetation from other resource management programs in combination with *Alternative 2*. These include feral ungulate control, alien plant control, and restoration with outplantings and direct seeding of native plants. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Wildlife. The policy of largely excluding fire would probably benefit most wildlife species because it protects native plant habitat upon which native birds and invertebrates depend. Prescribed fire in the Mid-Elevation Seasonal and Coastal Lowland Fire Management Units should improve native wildlife habitat, because it is a

tool for native vegetation restoration. Short-term disturbance of wildlife by wildland fire use or prescribed fire would be mitigated by consulting Resource Advisors to minimize impacts to wildlife.

Similar to *Alternative 1*, control of hazardous fuels to prevent their widespread establishment or to facilitate native revegetation efforts improves habitat quality for native wildlife in the long-term. Whenever possible, chemical and mechanical treatments would be conducted away from native bird habitat. Chemical treatments would be used as an initial knockdown of alien grasses. Long-term recurrent use of chemicals within a site would be avoided. The potential risk to wildlife would be mitigated by close consultation with resource advisors to avoid areas where native wildlife would be suspected of inhabiting. Integrated Pest Management guidelines would be used to ensure that the lowest effective herbicide dosage for treating grasses is applied, and to minimize impacts to the surrounding area. Consequently the effects of these treatments are expected to be minor to negligible.

Alternative 2 would have site specific and local, long term, direct and indirect, minor or potentially major beneficial, impacts on wildlife by excluding most fire and maintaining wildlife habitat. The effects of fire use on wildlife are expected to be largely beneficial because they are expected to be largely beneficial on native vegetation. Prescribed fire under *Alternative 2* may have localized long term beneficial impact on wildlife through habitat restoration. Combined with other restoration efforts, including feral ungulate control, alien plant control, invasive species control, and native plant community restoration there would be cumulative, beneficial impacts by restoring native ecosystem habitat. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Threatened and Endangered Species and Species of Special Concern. The nearly full suppression policy of *Alternative 2* protects threatened and endangered species and species of special concern by excluding fire from presumably fire sensitive species. Fire use and prescribed fire impacts on threatened and endangered species and species of special concern would be minimized by avoiding their application in areas with these species, unless these species are known to respond well to fire.

Prescribed fire may benefit some rare species. For example, Nene tend to utilize recently burned areas in the Mid-Elevation Seasonal and Coastal Lowland Fire Management Units. Furthermore, by helping restore native plant communities, prescribed fire may help restore habitat for rare species.

Similar to *Alternative 1*, control of hazardous fuels to prevent their widespread establishment or to facilitate native revegetation efforts improves habitat for threatened and endangered species and species of special concern in the long-term. Whenever possible, chemical and mechanical treatments would be conducted away from threatened and endangered species and species of special concern. The potential risk to threatened and endangered species and species of special concern would be

mitigated by close consultation with Resource Advisors to avoid areas where they are present. Integrated Pest Management guidelines would be used to ensure that the lowest dosage of herbicide that is effective in treating grasses was applied, and to minimize impacts to the surrounding area. Consequently the effects of these treatments would be expected to be minor to negligible.

Alternative 2 would have site specific and local, long term, direct and indirect, minor or potentially major, beneficial impacts on the threatened and endangered species and species of special concern. Excluding most fires would protect these species and their habitats by preventing the spread of invasive species after fire. Invasive species control and ecosystem restoration work in the park will have beneficial cumulative effects by maintaining or enhancing habitat for rare species. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Caves

By requiring suppression of most fires, *Alternative 2* protects caves from the negative impacts of fire resulting from the loss of `ohi`a roots. Fire may have an indirect, long-term effect on cave communities of invertebrates by killing overlying `ohi`a trees, including their roots, the main carbon source for cave food webs. Cave adapted organisms tend to be located in caves with high, constant relative humidity.

Suppression operations may expose caves to exploration and damage by fire fighters or others attracted to the site by an initial exploration. Visitation in the cave also damages `ohi`a root systems and the habitat for cave invertebrates. The potential impact of humans can be mitigated by avoiding areas with known cave resources, rerouting fire lines away from cave openings, and excluding access.

There is a greater chance that more cave resources may be affected by *Alternative 2,* which allows some fire use and prescribed fire.

Alternative 2 would have site specific, short and long term, direct and indirect, minor or possibly major beneficial impacts on the caves by excluding most fires and protecting `ohi`a roots in the caves. Adverse impacts from prescribed fire or fire use could be prevented by avoiding areas with caves. There would also be cumulative, beneficial impacts from park invasive species and ecosystem restoration programs. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Visitor Use and Experience

Alternative 2, which includes prescribed fire and fire use, may result in potentially more wildland fire and temporary visitor closures. However, the majority of the acreage targeted for prescribed fire is in lightly used park areas. This is particularly true of the dry `ohi`a woodlands in the Mid-Elevation Seasonal Fire Management Unit in lower

`Ainahou, the Hilina Pali Road and Trail areas, and the central and western coastal lowlands, west of Chain of Craters Road.

Visitors in automobiles would continue to be restricted from the lower portion of Hilina Pali Road and the Mauna Loa Road when the fire danger is very high or extreme. Use of the `Ainahou Road may also be restricted. In dry years, closures may be in effect for several weeks to several months of the year. There may be closures along the Hilina Pali Road during prescribed fire operations.

Alternative 2 would have site specific and local, short term, direct, minor adverse impacts on visitor use and experience. The impact of fire operations is cumulative with other administrative actions in the park such as the maintenance of facilities and resource management activities. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Socioeconomics

Alternative 2 impacts are expected to be similar to *Alternative 1* impacts because of the suppression of most wildand fires. As with *Alternative 1*, this may result in extended suppression efforts similar to those of 1987, 1992, 2000, and 2002-2003. Prolonged suppression efforts result in dramatically increased local purchases of helicopter, caterer, and lodging services and an increase in purchases for supplies and materials. Fire use and prescribed fire are not expected to reduce costs or expenditures significantly. Fire use will be limited to some isolated kipuka in three fire management units. Minimal staffing will be required. Prescribed fire is limited to two fire management units. Contingency staffing and helicopter support may be required. However, prescribed fires are expected to be short lasting because they will be conducted in grassy fuels.

A*lternative 2* would have local, minor, short term beneficial impacts on the economies of local communities during prolonged suppression efforts. The cumulative impact of this alternative on the local tourist-based economy is expected to be minor, with short term beneficial impacts.

Prime or Unique Farmlands

The largely fire exclusion policy of *Alternative 2* minimizes the potential for fires that start in the park to spread into adjacent and nearby prime or unique farmlands. The potential for soil erosion after fire and the potential for soil deposition on prime or unique farmlands is minimal. This is because of the rapid recovery of the vegetation and a largely fire suppression policy.

Fire use and prescribed fire would not affect prime or unique farmlands. Fire use is limited to the Alpine, Subalpine, and Coastal Lowland Fire Management Units (FMUs 1, 2, and 6). The prime or unique farmlands are adjacent to the Mid-Elevation Seasonal

and Montane Seasonal Fire Management Units (FMUs 4 and 5) where fire use is not allowed. Prescribed fire also will not put prime or unique farmlands at risk because it will not occur near them. Prescribed fire is allowed in the Coastal Lowland FMU, where there are extensive lava flows along the park boundaries, and in portions of the Mid-Elevation Seasonal FMU near the Hilina Pali Road, 3-10 miles from park boundaries and bordered by lava flows and dense rain forest.

Impacts of *Alternative 2* on prime or unique farmlands would be local, direct and indirect, minor, and largely beneficial because of fire suppression and weed control. Cumulative effects from park invasive species control and restoration programs would be minor or negligible but might benefit unique farmlands through control of invasive species.

CULTURAL ENVIRONMENT

Impact Definitions

NEPA recognizes three types of impacts—direct, indirect, and cumulative. Direct impacts are those that are caused at the same time and place as the action, indirect impacts occur later in time and at a distance, while cumulative impacts are additive. In regard to cultural resources and fire related effects, direct, operational, and indirect effect categories are utilized. Direct effects are those where the fire itself is the cause of the impacts, operational effects occur as a result of associated operations like line construction or staging, while indirect effects are ones where fire and/or associated operations result in changes to local context such that cultural resources will be effected. As such, direct and operational effects for cultural resources are the equivalent of direct impacts under NEPA, while indirect effects on cultural resources correspond to indirect and cumulative impacts. Effects also vary in terms of intensity and duration, and can be adverse or beneficial.

Direct Effects

Direct effects generated by wildland fire depend primarily on burn severity that is in turn dependent upon available fuels, terrain, and weather conditions. Direct impacts to stone artifacts and stone surface structures include thermal fracturing and spalling, and destabilization of surface structures by either burning of organic material embedded within the structure or by fire weakened trees and limbs falling on structures. Other impacts include the alteration of shell midden deposits and pollen remains within habitation complexes and agricultural features. Rock art sites including petroglyphs are susceptible to fire effects by sooting, discoloration, or in more severe burns cracking and spalling. Historic structures (wooden structures, fence lines, trail signage, etc.) are particularly vulnerable to fire effects regardless of burn severity. Impacts to glass, ceramics, and metal objects result from direct exposure to fire. Direct effects with the highest potential to impact sites and features within the park include fire deadened or weakened trees and root burn out that can destabilize surface architectural remains. To date, fire research concerning cultural resources has focused primarily on individual

artifact classes and has not examined broader cultural landscape effects except for overall environmental degradation within the post fire environment.

Fire suppression strategies and initial attack activities that utilize MIST (Minimum Impact Suppression Tactics) will minimize impacts to cultural resources. Consultation with the park's cultural resource specialists and personnel prior to suppression efforts will contribute to reducing these potential adverse impacts.

Operational Effects

Operational or suppression effects are those effects related to human efforts to suppress wildland fires. These effects in general result from landscape modification for spike camps (designated camp and staging areas for fire fighting personnel) and associated facilities, equipment staging areas, landing zones, and safety zones. Operational impacts also encompass suppression techniques that include hand line or machine line construction, explosive line construction, bucket drops, the use of fire retardants, and mop-up and rehabilitation efforts. Black lining, or creating a back fire to consume available fuels in front of the fire's path, and hose lays may also affect cultural resources within the fire environment. Operational effects with the highest potential to effect sites within the park include handline construction that can disturb sub-surface cultural remains or may collapse surface architectural features. Handline construction and bucket drops are the predominant fire line suppression techniques used within the park. Explosive line and dozer line are not utilized within the park's boundary as suppression tactics.

Indirect Effects

Indirect effects are negative effects that result in post fire environments that include increased surface runoff and erosion, increased tree mortality, and carbon contamination. Fire rehabilitation efforts may create negative effects through restoration of plant communities requiring outplanting activities. Increased surface visibility of archeological remains and surface artifacts may contribute to increased site disturbance and looting activity within the fire environment. Indirect effects most likely to impact sites within the park include carbon contamination and rehabilitation efforts that have ground disturbing activities. The indirect effects associated with erosion are not as prominent within Hawai`i Volcanoes National Park. The surface lava and substrate are highly permeable and excessively drained with minimal soil development in many places in the park. This geographic condition reduces the post fire erosion effects to the sites and features within the park. Erosional episodes have been observed along the coastal portion of the park and within the Ka`u Desert. These events were preceded by unusual heavy rains with 30+ inches of rainfall occurring in a 24-hour period.

Observed Effects

Fire effects on archeological resources (temporary habitation features including C-shapes, terraces, platforms, habitation shelters and caves, trails and trail markers,

petroglyphs, enclosures, walls, and agricultural features including mounds and excavated pits) were most closely observed during the 2002 Kupukupu Fire. These effects were documented on pre-and post-burn forms that recorded pre-existing site conditions and post-burn conditions for located archeological features. Burn severity was primarily restricted to low-moderate severity. No vandalism was noted during the post fire assessment, and three types of fire effects were noted on feature types that include smoke/soot damage, stump/root holes, and tree(s) on walls or rubble. Few suppression impacts were noted during the survey and they were limited to the Kalapana Trail (Site 20443). Impacts consisted of the dislocation of basalt cobbles that lined portions of the trail; the impacts represent an insubstantial alteration of the non-maintained trail route.

Alternative 1 (No Action) Impact Analysis

The fire suppression and experimental use of prescribed fire in *Alternative 1* potentially impacts cultural resources. Known cultural resources would be protected under *Alternative 1* by close consultation with cultural resource specialists and fire personnel. When possible, cultural resources would be avoided. However, damage to unknown sites and features through fire suppression activity (operational impacts) could occur and could include impacts associated with staging operations, fire line construction, heli-spot construction, retardant application, and mop-up efforts. Wildland fire suppression activities have the potential to impact and adversely affect archeological features and sites and historic structures, and they can potentially alter ethnographic and cultural landscapes. Fire suppression activities produce ground disturbing activities that can adversely affect both surface and buried archeological remains. It is recommended that cultural resource personnel accompany fire fighting crews during suppression efforts and prescribed fire activities. Precautions regarding cultural resource protection are critical given that only a small fraction (less than 2%) of the current park area has been surveyed, and suppression activities generally occur in remote sections of the park that have received little or no systematic archeological survey.

Under *Alternative 1*, the park's cultural resources staff will provide consultation (e.g., maps) for fire suppression activities, prescribed fire, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas that occur in the vicinity of known historic or archeological sites. Their direct involvement when choosing locations for fire camps, staging areas, fire lines, revegetation, establishing fuel breaks, etc., would substantially help in avoiding or minimizing adverse impacts. Cultural resources would be avoided when possible. Mitigation efforts could reduce or eliminate the negative impacts on the park's known and unknown cultural resources, and lessen the chances of adverse impacts to sites and features. If a prescribed fire will negatively impact cultural resources and the impact(s) could not be mitigated, then the prescribed fire will not occur.

Alternative 1 would have site specific, direct and indirect, short and long term, minor impacts on cultural resources. There may be cumulative effects on cultural resources

from natural resource management invasive species control and native plant community restoration projects. The outcome of these projects is the removal of ungulates that may disturb cultural features and the removal of invasive plant species manually, mechanically, or chemically. Restoration programs may involve outplanting and direct seeding of native vegetation. The net outcome of invasive species control and restoration could be a benefit to cultural resources by removing impacts from ungulates and removing impacts or sources of impacts resulting from invasive species. However, cultural resources could also be impacted by the removal of invasive species (such as loss of stability if vegetation is growing in an archeological features) and the recovery or establishment of native vegetation. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Alternative 2 (Proposed Action) Impact Analysis

Under *Alternative 2*, similar impacts to cultural resources from fire suppression efforts can be anticipated. Reduced suppression efforts within Coastal Lowland and the Alpine and Subalpine Fire Management Units will effectively reduce suppression related impacts in these units. Based on the remoteness of kipuka in the Subalpine and Alpine Fire Management Units, it is unlikely that archeological or cultural resources will be present at these isolated locations. However, they should still be surveyed for cultural resources before the fire occurs. When coastal lowland kipuka are being considered for fire use, they should be examined for cultural resources before the fire occurs, unless conditions are not safe for survey personnel.

Prescribed fire treatments may increase with *Alternative 2*. The expanded use of prescribed fire may increase the potential impacts to both previously documented features and sites and unknown feature and site locations. All areas subjected to prescribed fire treatments should be surveyed for cultural resources prior to burn implementation. Sites identified through survey efforts will be evaluated for site significance (National Register eligibility) and potential effect determinations will be generated. If the prescribed burn will negatively impact National Register eligible or listed resources, and these impacts can not be successfully mitigated, then the prescribed fire treatment will not occur. Additionally, post-fire assessments should be conducted to evaluate fire effects and to survey for previously unidentified archeological features and sites. If an archeological survey is not feasible prior to a prescribed fire (e.g., dense vegetation), then the post-fire area should be thoroughly examined for cultural resources as soon as possible after the prescribed fire is extinguished and mop-up operations are completed.

Prescribed fire locations will not generally occur near historic structures. However, in the case that prescribed fires escape suppression efforts, and historic structures are threatened, the appropriate protection measures (e.g., fire breaks, foam retardants) will be implemented to reduce negative effects to these threatened structures. Prescribed fires will not occur within identified cultural landscapes or documented ethnographic resource areas if the fire would negatively impact the resource(s) and the impacts could

not be mitigated. If these resources are threatened by escaped fire during prescribed fire activities, then suppression efforts will be directed toward protecting these documented resources.

As with *Alternative 1*, the park's cultural resources staff will provide consultation (e.g., maps) for manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas that occur in the vicinity of known historic or archeological sites. Their direct involvement when choosing locations would substantially help in avoiding or minimizing adverse impacts. Mitigation efforts could reduce or eliminate the negative impacts on the park's known and unknown cultural resources, and lessen the chances of adverse impacts to sites and features.

Alternative 2 would have site specific and local, direct and indirect, short and long term, minor impacts on cultural resources. As with *Alternative 1*, there may be cumulative effects on cultural resources from natural resource management invasive species control and native plant community restoration projects. The outcome of these projects is the removal of ungulates that may disturb cultural features and the removal of invasive plant species manually, mechanically, or chemically. Restoration programs may involve outplanting and direct seeding of native vegetation. The net outcome of invasive species control and restoration is the recovery or establishment of native vegetation, which may impact cultural resources. This alternative would not impair park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Table 5. Summary of Impact Topics, Alternatives, Impacts, and Mitigation.

IMPACT CATEGORY	ALTERNATIVE 1	ALTERNATIVE 2
	Alternative 1. Suppress all unplanned human-caused fires. All fires of natural origin will be suppressed, including all lightning and lava caused fire. Allow the experimental use of prescribed fire in those areas of the park where there are extensive barriers to fire spread past park boundaries. *Continue to control invasive fountain grass and other fuels, maintain fuel breaks in fire-prone areas or at high value resource areas, and revegetate burned areas with fire-tolerant native vegetation, if feasible and necessary. Limited use of manual and chemical treatments would continue to prevent the widespread establishment of new alien species and facilitate native plant revegetation, including rare plants.*	*Alternative 2. All unplanned fires of human origin will be suppressed. All fires of natural origin will be suppressed except for fires in isolated kipuka in the Coastal Lowland, Alpine, and Subalpine FMUs that are surrounded by extensive lava flows and where resource damage such as loss of rare species or expected invasion of alien species would not occur. Prescribed fire may be used in the Coastal Lowland and Mid-Elevation Seasonal FMUs to help restore native vegetation or threatened, endangered, or rare species in environments altered by invasive species. Fire use and prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries.* *Continue to control invasive fountain grass and other fuels, maintain fuel breaks in fire-prone areas or at high value resource areas. Revegetate burned areas with fire-tolerant native vegetation, if feasible and necessary. Limited use of manual and chemical treatments would continue to prevent the widespread establishment of new alien species and facilitate native plant revegetation, including rare plants.*
Air Quality	Local, direct and indirect, short term negligible to minor, adverse impacts. Smoke production minimized by suppressing all fires and a minimal role for prescribed fire.	Local, direct and indirect, short term negligible to minor, adverse impacts. Greater smoke production because of potential for limited wildland fire use and prescribed fire. Minimize smoke production by conducting prescribed fires only when conditions favor smoke dispersal.
Soils	Site specific, short term, indirect, negligible to minor, adverse impacts because of vegetation recovery or persistence of litter and humus.	Site specific and local, short and long term, indirect, minor, adverse impacts because of vegetation recovery or persistence of litter and humus. Minimize erosion potential by avoiding intense prescribed fires.
Water Resources and Wetlands	Site specific and local, short and long term, indirect, negligible impacts because of low fire potential in the vicinity of water resources and wetlands, and mitigation using	Site specific and local, short and long term, indirect, negligible impacts because of low fire potential in the vicinity of water resources and wetlands. Minimize potential

IMPACT CATEGORY	ALTERNATIVE 1	ALTERNATIVE 2
	Minimum Impact Suppression Tactics (MIST) to avoid contamination of water resources.	contamination by using MIST, such as avoiding use of retardants and foam near water resources. Expanded use of prescribed fire and wildland fire use does not include areas containing water resources and wetlands.
Wilderness	Local, short and long term, direct and indirect, minor, adverse impacts such as helicopter flights, chain saw, weed eater use, landing zones, fire lines, and safety zones. These actions have been determined in past fires to be Minimum Tools. Potential for long-term impacts mitigated by use of Minimum Requirement/Minimum Tool decision-making process, MIST, and revegetation of fire damaged areas. Enhanced wilderness quality through limited restoration of alien dominated communities through revegetation after wildfire, small experimental prescribe burns, and manual/chemical clearing of invasives.	Local, short and long term, direct and indirect, minor, adverse impacts of fire operations similar to Alternative 1. These actions have been determined in past fires to be Minimum Tools. Potential for fewer suppression impacts in wilderness because of fire use policy in portions of three FMUs. Potential for more fire and fire suppression impacts in portions of Coastal Lowland and Mid Elevation Seasonal FMUs because of prescribed fire. Potential for long-term impacts mitigated by use of Minimum Requirement/Minimum Tool decision-making process, MIST, and revegetation of fire damaged areas. Provides for more widespread improvement of wilderness qualities of ecological integrity and biodiversity through expanded use of prescribed fire and wildland fire use in areas overwhelmed by invasives, followed by revegetation with native plant species. These activities would be undertaken following a Minimum Requirement/Minimum Tool analysis.
Soundscapes	Site specific and local, short term, direct and indirect, negligible adverse impacts on soundscapes because of use of helicopters and power tools such as chain saws and weed eaters.	Site specific and local, short term, direct and indirect, negligible adverse impacts on soundscapes because of use of helicopters, chain saws, and weed eaters. Potentially more extensive impacts because of fire use and prescribed fire.
Wildland/Urban Interface	Local, long term, direct and indirect, negligible beneficial impacts. Provides for maximum protection of life, property, and resources in the wildland/urban interface because it requires all fires to be suppressed, does not allow fire use, and includes only a minimal role for prescribed fire in the park. Prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park	Local, long term, direct and indirect, negligible beneficial impacts. Mitigation for fire use and prescribed fire provides for protection of life, property, and resources in the wildland/urban interface. Fire use and prescribed fire will be allowed only in those areas of the park where there are extensive barriers to fire spread past the park boundaries.

IMPACT CATEGORY	ALTERNATIVE 1	ALTERNATIVE 2
	boundaries.	
Vegetation	Site specific and local, long term, direct and indirect, minor or potentially major, beneficial impacts. Protection of native plant communities from spread of invasive plants through fire exclusion. Protection of fire-sensitive native plant communities and rare plant sites from fire through fire exclusion. Use of Resource Advisors to protect sensitive vegetation. Limited restoration of native plant communities through revegetation following wildfire, small experimental prescribed fires, and manual/chemical treatments of invasive grasses.	Site specific and local, long term, direct and indirect, minor or potentially major, beneficial impacts. Protection of native plant communities from spread of invasive plants through fire exclusion. Protection of fire-sensitive native plant communities through fire exclusion. Use of Resource Advisors to protect sensitive vegetation. Expanded restoration of native vegetation in alien dominated communities through prescribed fire in areas overwhelmed by invasives, followed by revegetation. *Alternative 2* will also contribute the most information about fire effects on vegetation.
Wildlife	Site specific and local, long term, direct and indirect, minor or potentially major, beneficial impacts. Protection of native wildlife through exclusion of fire in native habitats. Limited improvement of habitat through revegetation following small experimental prescribed fires and natural wildfire. Use of Resource Advisors to protect sensitive species and habitat.	Site specific and local, long term, direct and indirect, minor or potentially major, beneficial impacts. Protection of native wildlife through exclusion of fire from native habitats; enhanced wildlife habitat in Coastal Lowland and Mid-Elevation Seasonal FMUs. Expanded improvement of habitat through prescribed fire followed by revegetation. Use of Resource Advisors to protect sensitive species and habitat.
Threatened/ Endangered Species and Species of Special Concern	Site specific and local, long term, direct and indirect, minor or potentially major, beneficial impacts. Fire exclusion under this alternative best protects rare species. Use of Resource Advisors to protect sensitive species and habitat.	Site specific and local, long term, direct and indirect, minor or potentially major, beneficial impacts. There is potential for more extensive impacts on rare species because of fire use and prescribed fire. However, fire would not be allowed or used in areas with rare species unless these species were known to respond favorably or can be protected from fire. Prescribed fire may enhance rare species populations in Coastal Lowland and Mid-Elevation Seasonal FMUs because of plant community or habitat restoration.
Caves	Site specific, short and long term, direct and indirect, minor or possible major, beneficial impacts to `ohi`a roots and cave organisms and	Site specific, short and long term, direct and indirect, minor or possible major, beneficial impacts. Potentially more extensive impacts to cave

IMPACT CATEGORY	ALTERNATIVE 1	ALTERNATIVE 2
	environment by fire exclusion. Potential for visitation and impacts in caves by fire fighters. Use of Resource Advisors to protect caves during fire operations.	ecosystems with prescribed fire and fire use. These can be mitigated by avoiding areas with known cave resources. Use of Resource Advisors to protect caves during fire operations.
Visitor Use and Experience	Site specific and local, short term, direct and indirect, negligible minor adverse impacts from restricting visitors from parts of the park because of fire or fire operations or loss of viewsheds because of smoke. Interpretation of fire use and prescribed fire on site as mitigation.	Site specific and local, short term, direct and indirect, minor adverse impacts. Potential for more closures and smoke with fire use and prescribed fire. Interpretation of fire use and prescribed fire on site as mitigation
Socioeconomics	Local, short term, direct and indirect, minor beneficial impacts on the economy of local communities.	Local, short term, direct and indirect, minor beneficial impacts on the economy of local communities.
Prime or Unique Farmlands	Local, direct and indirect, short and long term, minor, largely beneficial impacts. Fire exclusion policy provides maximum protection for unique farmlands. Prescribed fire will not occur near prime or unique farmlands.	Local, direct and indirect, short and long term, minor, largely beneficial impacts. Largely fire exclusion policy minimizes potential for fire to leave the park and affect unique farmlands. Fire use not allowed in the FMUs that are near the unique farmlands. And the prime or unique farmlands are not near the areas where prescribed fire is allowed.
Archeological Resources	Site specific, direct and indirect, short and long term, minor impacts. Possible impacts to resources from suppression activities. Mitigate impacts through consultation with Cultural Resources staff for fire planning and implementation, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No prescribed fire if negative (adverse) impacts can't be mitigated.	Site specific and local, direct and indirect, short and long term, minor impacts. Reduced impacts from fire suppression activities; however, possible increased impacts from direct fire effects. Similar consultation efforts as presented in *Alternative 1* for fire planning and implementation, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No natural fire or prescribed fire use if negative (adverse) impacts can't be mitigated.
Historic Structures	Site specific, direct and indirect, short and long term, minor impacts. Possible impacts to resources from suppression activities. Mitigate impacts through consultation with Cultural Resources staff for fire planning and implementation, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants,	Site specific and local, direct and indirect, short and long term, minor impacts. Similar consultation efforts as presented in *Alternative 1.* Possible impacts to resources from suppression activities. Mitigate impacts through consultation with Cultural Resources staff for fire planning and implementation, manual and chemical treatments to prevent

IMPACT CATEGORY	ALTERNATIVE 1	ALTERNATIVE 2
	controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No prescribed fire if negative (adverse) impacts can't be mitigated.	new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No prescribed fire if negative (adverse) impacts can't be mitigated.
Cultural Landscapes	Site specific, direct and indirect, short and long term, minor impacts. Possible impacts to resources from suppression activities. Mitigate impacts through consultation with Cultural Resources staff for fire planning and implementation, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No prescribed fire if negative (adverse) impacts can't be mitigated.	Site specific and local, direct and indirect, short and long term, minor impacts. Reduced impacts from fire suppression activities; however, possible increased impacts from direct fire effects. Similar consultation efforts as presented in *Alternative 1* for fire planning and implementation, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No natural fire or prescribed fire use if negative (adverse) impacts can't be mitigated.
Ethnographic Resources	Site specific, direct and indirect, short and long term, minor impacts. Possible impacts to resources from suppression activities. Mitigate impacts through consultation with Cultural Resources staff for fire planning and implementation, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No prescribed fire use if negative (adverse) impacts can't be mitigated.	Site specific and local, direct and indirect, short and long term, minor impacts. Reduced impacts from fire suppression activities; however, possible increased impacts from direct fire effects. Similar consultation efforts as presented in *Alternative 1* for fire planning and implementation, manual and chemical treatments to prevent new alien grass establishment and facilitate revegetation of native plants, controlling fountain grass, maintaining or establishing fuel breaks, and revegetating burned areas. No natural fire or prescribed fire use if negative (adverse) impacts can't be mitigated.

REGULATORY COMPLIANCE

NATIONAL ENVIRONMENTAL POLICY ACT

This Environmental Assessment (EA) was prepared in compliance with the National Environmental Policy Act (NEPA) of 1969 and its implementing regulations. A preferred action alternative was developed and analyzed in conjunction with a no action alternative. The EA is being made available to the public for a 30-day review. Upon completion of the public review, the National Park Service will assess public comments and may modify the preferred alternative as appropriate. If the National Park Service (NPS) park superintendent and the Pacific West Regional Director decide, based on this EA and any substantive comments received, that the Fire Management Plan would significantly effect the human environment, a notice of intent (NOI) to prepare an environmental impact statement (EIS) would be issued. A Finding of No Significant Impact (FONSI) would be issued if it is determined that there would be no significant impact from the Fire Management Plan Environmental Assessment's projects, studies, or other program elements, which may be implemented later in carrying out the approved Fire Management Plan as evaluated in the EA. The Pacific West Regional Director would approve the FONSI.

This is a programmatic EA in that it establishes a direction for overall fire management within the park. Additional NEPA compliance may be necessary for site-specific actions or projects not fully addressed in this document (e.g., another EA may be needed for a fuel break).

ENDANGERED SPECIES ACT

Section 7 of the Endangered Species Act (ESA) requires federal agencies to consult with the U.S. Fish and Wildlife Service (USFWS) on any action that may affect endangered or threatened species or candidate species, or that may result in adverse modification of critical habitat. As part of the consultation process for this EA, the NPS would seek USFWS concurrence with its determination of effect.

EXECUTIVE ORDER 11990 (PROTECTION OF WETLANDS)

Executive Order 11990 directs the NPS to avoid, to the extent possible, the long- and short-term adverse impacts associated with modifying or occupying wetlands. The NPS is required to avoid direct or indirect support of wetland development whenever there is a practical alternative. The EA alternatives do not include areas containing wetlands. There would be no long- or short-term adverse impacts and wetlands would not be modified or occupied. There would be no direct or indirect support of wetland development. Impacts of both alternatives on wetlands would be negligible.

The potential for fire spread near wetlands is extremely low. Fuels are sparse and intermittent. Under the proposed Fire Management Plan, using the MIST approach to fire suppression, which includes consultation with Resource Advisors and avoidance of

chemical usage near wetlands, the potential for contamination to wetlands is very low. The limited use of manual and chemical treatments to prevent widespread establishment of invasive grasses is extremely localized and is prohibited in the vicinity of wetlands. In addition, Integrated Pest Management guidelines are used to ensure that the lowest dosage of herbicide that is effective in treating grasses is applied.

NATIONAL HISTORIC PRESERVATION ACT

Section 106 of the National Historic Preservation Act (NHPA) of 1966 and its implementing regulations requires federal agencies to consider the effects of their undertakings on historic properties (resources that have been determined eligible or are listed on the National Register of Historic Places), and to provide State Historic Preservation Officers (SHPO) and as necessary, the Advisory Council on Historic Preservation (Council), a reasonable opportunity to review and comment on these actions. Section 106 also requires federal agencies to consult with Native Hawaiian organizations about the effects of their undertakings on resources of traditional religious or cultural importance eligible for listing or listed on the National Register. The information and mitigation gathered as part of the section 106 consultation must be included in the NEPA document.

As part of the consultation process for this EA, the NPS would consult with the Hawai`i SHPO, the Council (as necessary), Historic Hawai`i Foundation, and Native Hawaiian organizations including the Office of Hawaiian Affairs, Edith Kanaka`ole Foundation, Hui Malama I Na Kupuna O Hawai`i Nei, Kamehameha Schools Bishop Estate, and the Big Island Burial Council; as well as the park's Kupuna Consultation Group. As part of the consultation process for this EA, the NPS would seek to identify concerns; the potential for impact on cultural resources; develop appropriate mitigation measures, as necessary; and seek concurrence with the determination of effect.

PLANNING TEAM AND CONSULTANTS

Dennis Dougherty, Archeologist, Hawai`i Volcanoes National Park.

Dr. David Foote, Research Biologist, U.S. Geological Survey (U.S.G.S.), Biological Resources Division, Pacific Islands Ecosystems Research Center.

Lynn Gasser, Archeologist, Whiskeytown National Recreation Area.

Dr. Sara Hotchkiss, University of Wisconsin.

Aleta Knight, Management Assistant, Hawai`i Volcanoes National Park.

Catherine Lentz, Compliance Manager, Hawai`i Volcanoes National Park.

Rhonda Loh, Botanist, Hawai`i Volcanoes National Park.

Dr. Jadelyn Moniz Nakamura, Integrated Resource Manager, Hawai`i Volcanoes National Park.

Linda Pratt, Botanist, U.S.G.S., Biological Resources Division.

Dr. Thane Pratt, Research Biologist, U.S.G.S., Biological Resources Division.

Laura C. Schuster, Cultural Resources Manager, Hawai`i Volcanoes National Park.

Nelson Siefkin, Fire Archeologist, Pacific West Region, National Park Service.

Dr. Don Swanson, Research Geologist, U.S.G.S., Hawaiian Volcano Observatory.

Tim Tunison, Chief of Resources Management, Hawai`i Volcanoes National Park.

Rick Warshaurer, Research Associate, U.S.G.S., Biological Resources Division.

EA RECIPIENTS – AGENCIES, ORGANIZATIONS, LIBRARIES, AND STATE AND LOCAL GOVERNMENT REPRESENTATIVES

Big Island Visitor Bureau
Damon Estate
Department of Land and Natural Resources, Division of Forestry and Wildlife
Environment Hawaii Inc.
The Nature Conservancy of Hawai`i
Office of Hawaiian Arts
University of Hawai`i – Manoa, Department of Zoology
Conservation Council of Hawai`i
Council for Native Hawaiian Advancement
Pacific Cooperative Studies Unit, University of Hawai`i - Manoa, Botany Department
Department of Land and Natural Resources, Olinda Endangered Species Facility
Earth Justice
Hawai`i Natural History Association
Hawai`i County Planning Director
Volcano House
University of Hawai`i – Manoa, Department of History
National Park Service, Pacific West Region
U.S. Geological Survey, Pacific Island Ecosystems Research Center
Hawai`i Audobon Society
U.S. Geological Survey, Hawaiian Volcano Observatory
U.S. Fish and Wildlife Service, Pacific Islands Ecoregion
Sierra Club
Chamber of Commerce – Hilo
KMC at Kilauea Volcano
The Kalapana Ohana
University of Hawai`i – Manoa, Department of Botany

Volcano Art Center
Hawai`i County Fire Department
Haleakala National Park
University of Hawai`i – Hilo, Office of Mauna Kea Management
Japanese Chamber of Commerce – Hilo
University of Hawai`i – Hilo, Extension Services
Volcano Community Association
Historic Hawai`i Foundation
Edith Kanaka`ole Foundation
Kamehameha Schools
Office of Hawaiian Affairs
Hui Malama I Na Kupuna O Hawai`i Nei
Big Island Burial Council
Department of Land and Natural Resources, State Historic Preservation Officer
The Honorable Harry Kim, Mayor of the Island of Hawai`i
The Honorable Russel Kokobun, State Senator
The Honorable Linda Lingle, Governor of Hawai`i
East Hawai`i Governor's Liaison Officer
The Honorable Neil Abercrombie, Representative in Congress
The Honorable Ed Case, Representative in Congress
The Honorable Daniel Akaka, United States Senator
The Honorable Daniel K. Inouye, United States Senator
Hawai`i State Library
Bond Memorial Public Library
Hilo Public Library
Holualoa Public Library
Honoka`a Public Library
Kailua-Kona Public Library
Kea`au Public Library
Kealakekua Public Library
Laupahoehoe Public Library
Mountain View Public Library
Na`alehu Public Library
Pahala Public Library
Thelma Parker Public Library

The EA was also sent to 57 interested members of the public.

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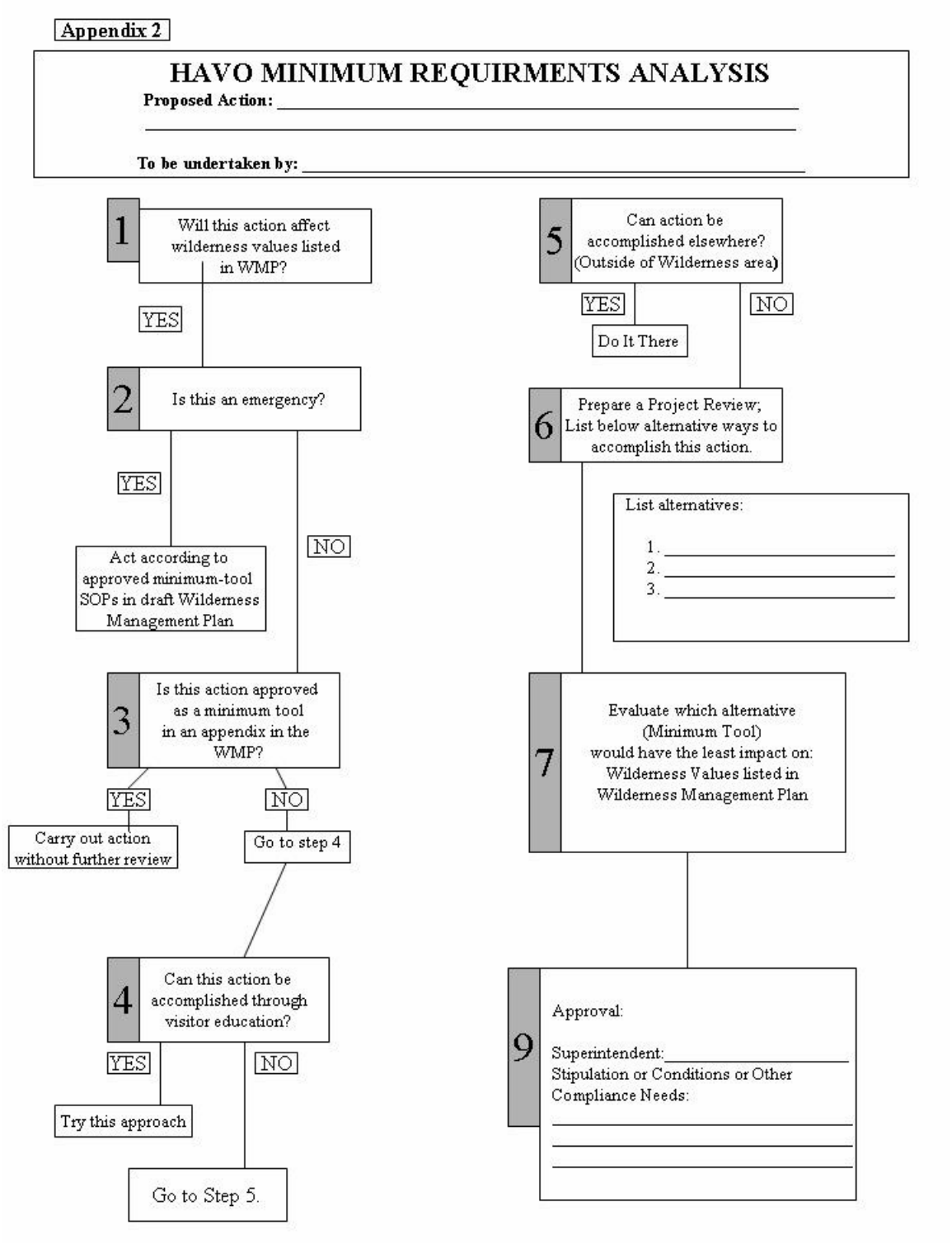
Appendix 1. Common and Scientific Names Used in this Document.

COMMON NAME	***SCIENTIFIC NAME***
`A`a`li`i	*Dodonaea viscosa*
A`e	*Zanthoxylum hawaiiense*
`Ahakea	*Bobea timonioides*
`Aiea	*Nothocestrum breviflorum*
`Akepa	*Loxops coccineus*
`Akia	*Wikstroemia sandwicensis*
`Akala	*Rubus hawaiiensis*
`Akiapola`au	*Hemignathus munroi*
`Akoko	*Chamaesysce celastroides*
`Aku	*Cyanea tritomantha*
Alani	*Melicope zahlbruckneri*
`Amakihi	*Hemignathus virens*
`Anuanu	*Sicyos macrophyllus*
`Apapane	*Hematone sanuinea*
(no common name)	*Asplenium peruvianum var. fragile*
`Awapuhi a kanaloa	*Liparis hawaiensis*
Barbwire grass	*Cymbopogon refractus*
Beardgrass	*Schizarchium condensatum*
Broomsedge	*Andropogon virginicus*
(no common name)	*Drosophila engrochracea*
(no common name)	*Drosophila mimica*
Blackburn Butterfly	*Udara blackburni*
Christmasberry	*Schinus terebinthifolius*
`Elepaio	*Chasiempis sandwichensis*
Faya tree	*Morella faya*
Feral goat	*Capra hircus*
Hairgrass	*Deschampsia nubigena*
Halapepe	*Pleomele hawaiiensis*
Happyface Spider	*Theridion gralaitor*
Hau kauhiwi	*Hibiscdelphus giffardianus*
Hawai`i Creeper	*Oreomystis mana*
Hawaiian catchfly	*Silene hawaiiensis*
Hi`awale	*Cyrtandra giffardii; C. tintinabula*
Hoawa	*Pittosporum terminaliodes*
Holei	*Ochrosia kilaueaensis*
Humuloa	*Exocarpos gaudichaudii*
`Io	*Buteo solatarius*
`I`iwi	*Vestiaria coccinea*
(no common name)	*Ischaemum byrone*
Kamehameha Butterfly	*Vanessa tameamea*
Kauila	*Alphitonia ponderosa*
Kihi	*Adenophorus periens*

COMMON NAME	***SCIENTIFIC NAME***
Kikuyugrass	*Pennisetum clandestinum*
Kilioe	*Embelia pacifica*
Koa	*Acacia koa*
Koki`o	*Kokia drynariodes*
Koli`i	*Trematolobelia grandifolia*
Ko`oko`olau	*Bidens hawaiensis*
Lama	*Diospyros sandwicensis*
Laukahi kuahiwi	*Plantago hawaiensis*
Loulu palm	*Pritchardia affinis*
Long horned beetles	*Plagithmysus spp.*
Mamaki	*Pipturus albidus*
Manele	*Sapindus saponaria*
Mamane	*Sophora chrysophylla*
Mauna Loa silversword	*Argyroxiphium kauense*
Meadow ricegrass	*Ehrharta stipoides*
Molasses grass	*Melinis minutiflora*
Natal redtop	*Melinis repens*
Napuka kahakai	*Scaevola sericea*
Naupaka kuahiwi	*Scaevola kilaueae*
Nene	*Nesochen sandvicensis*
`Ohe	*Joinvillea ascendens var. ascendens*
`Ohe makai	*Reynoldsia sandwicensis*
`Ohe mauka	*Tetraplasandra hawaiiensis*
`Ohawai	*Clermontia spp.*
`Ohelo	*Vaccinium reticulatum*
`Ohai	*Sesbania tomentosa*
`Ohi`a	*Metrosideros polymorpha*
`Oma`o	*Myadestes obscurus*
(no common name)	*Phyllostegia floribunda*
Papala kepau	*Pisonia umbellifera*
Pili grass	*Heteropogon contortus*
Pilo	*Coprosma spp.*
(no common name)	*Portulaca villosa*
Peuo	*Asio flammeus sandwichensis*
Pukiawe	*Leptecophylla tameiameiae*
Scaly sword fern	*Nephrolepis multiflora*
Southern house mosquito	*Culex quinquefasciatus*
Sweet vernal grass	*Anthoxanthum ordoratum*
Thatchinggrass	*Hyparrhenia rufa*
Two spotted leafhopper	*Sophonia rufofascia*
Uhaloa	*Waltheria americana*
`Ulei	*Osteomeles anthyllidifolia*
Uluhe	*Dicranopteris linearis*
Velvet grass	*Holcus lanatus*
Yellow faced bees	*Hylaeus spp.*

Appendix 2. Minimum Requirement/Minimum Tool decision-making process in the draft Wilderness Management Plan currently being followed in all park operations including fire management. During fire operations, Resource Advisors will facilitate this process.



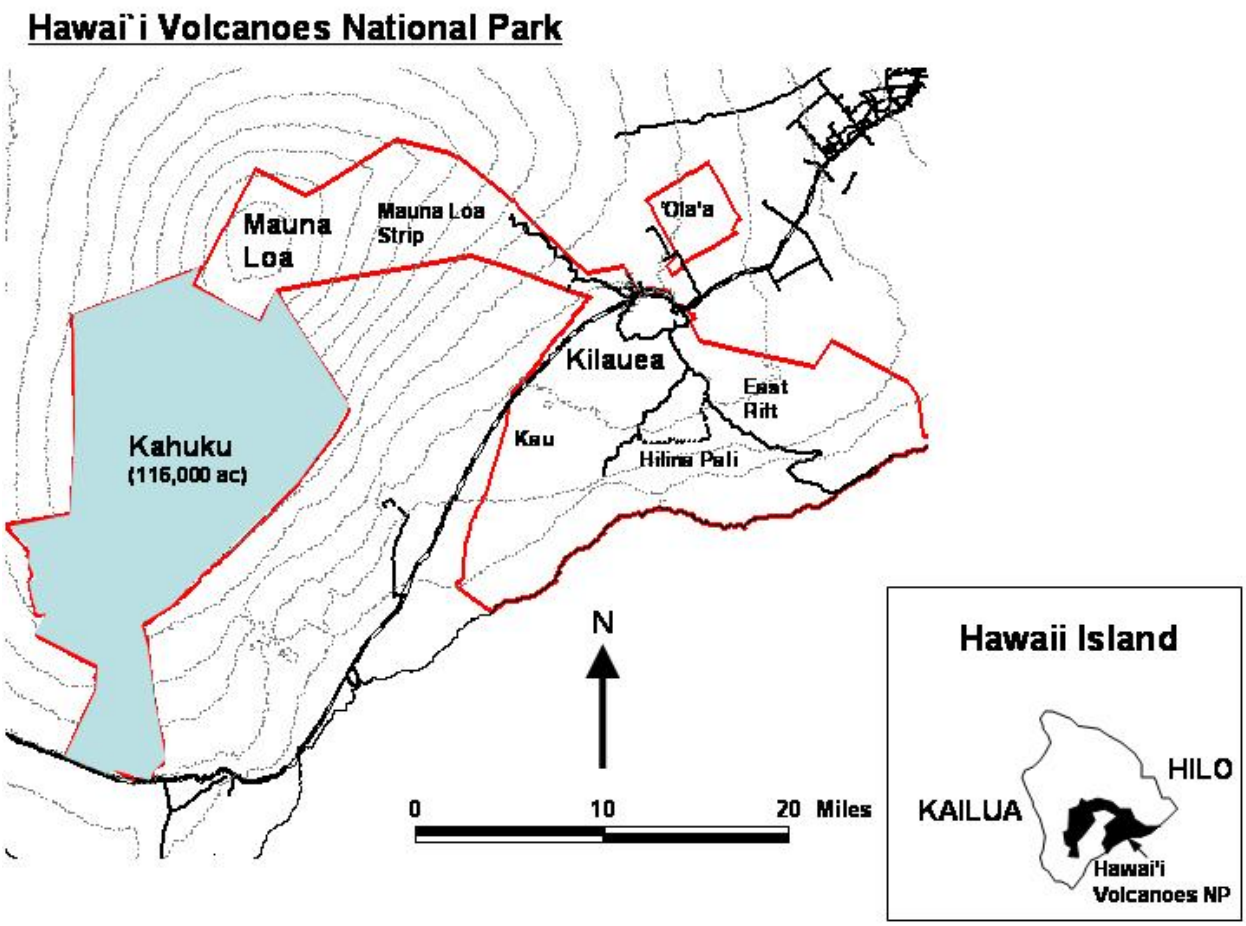


Figure 1. Place Names, Hawai`i Volcanoes National Park.

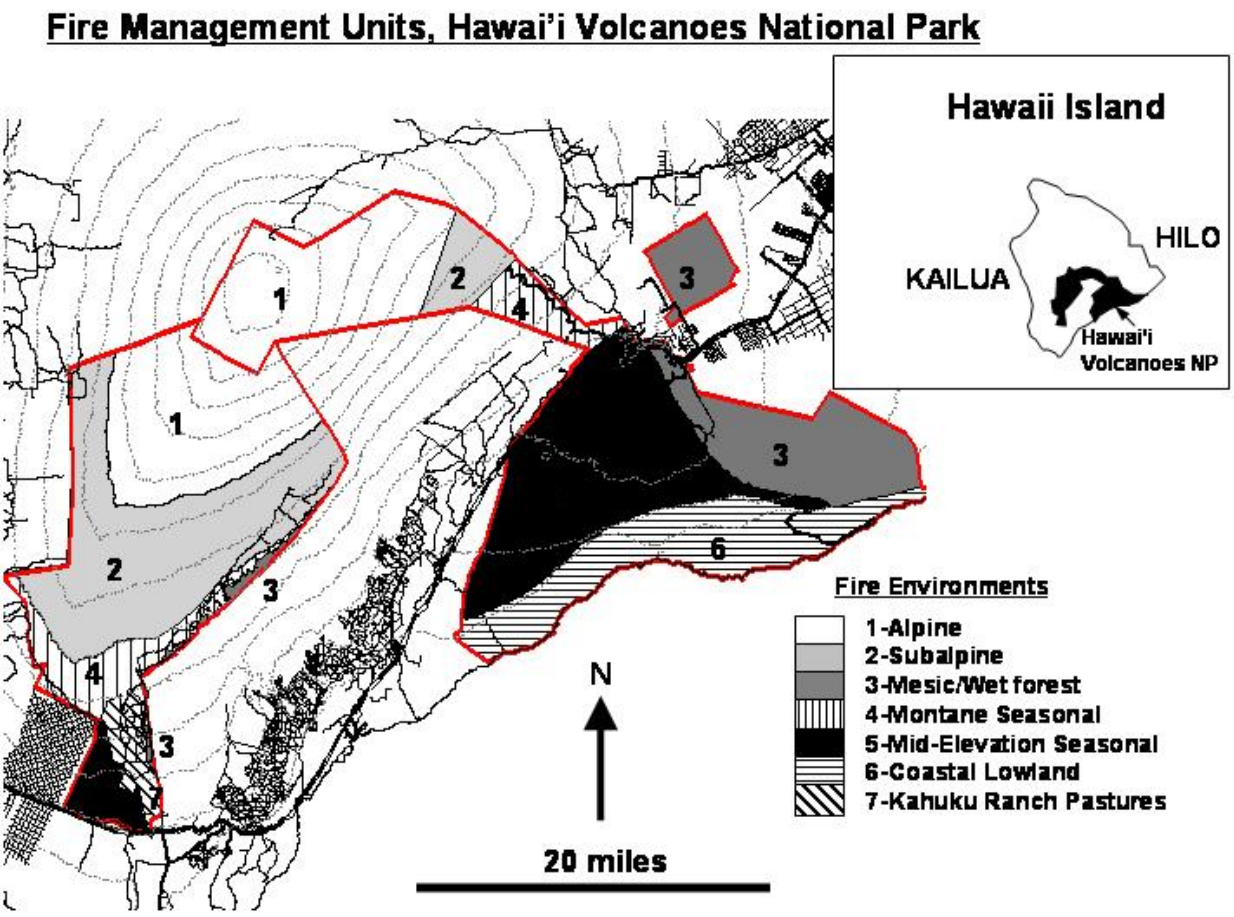


Figure 2. Fire Environments, Hawai`i Volcanoes National Park.